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DRAFT FEASIBILITY STUDY SITE 11 SCHOOL OF MUSIC PLATING SHOP NAB LITTLE CREEK VA
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Draft

Feasibility Study

Site 11 - School of Music Plating Shop

Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Contract Task Order N62470-95-6007
CTO-0159

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Prepared by

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Executive Summary

This report presents the Feasibility Study (FS) for Site 11, the former School of Music Plating Shop at Naval Amphibious Base (NAB) Little Creek. This FS is prepared by CH2M HILL under the Naval Facilities Engineering Command (NAVFAC), Atlantic Division Comprehensive Long-Term Environmental Action Navy II (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 0159, for submittal to NAVFAC, the United States Environmental Protection Agency (USEPA), and the Virginia Department of Environmental Quality (VDEQ).

Contamination at Site 11 consists of a volatile organic compound (VOC) groundwater plume including a residual source area (sorbed mass and aqueous phase contaminants) and a down-gradient plume. This site is located in the eastern portion of the base, near the intersection of Seventh and E Streets and consisted of the plating shop (Building 3651), an in-ground concrete tank used to neutralize plating solutions, and its associated piping. The tank and associated soil and piping have been removed.

This FS summarizes the nature and extent of the contaminated groundwater at Site 11, defines the remedial action objective (RAO), evaluates remedial action alternatives for the RAO, and identifies the applicable or relevant and appropriate requirements (ARARs). Following screening of groundwater treatment technologies of the source and plume area, the three alternatives retained for detailed evaluation and comparative analysis include:

Alternative 1 - No Action
Alternative 2 - Enhanced Reductive Dechlorination (ERD)
Alternative 3 - Electrical Resistance Heating (ERH) and Enhanced Reductive Dechlorination (ERD)

This FS provides a detailed analysis of each alternative against the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) criteria followed by the comparative analysis of the remedial alternatives against one another. Alternative 1 is required by the NCP as a baseline. It does not meet the statutory requirements of the NCP and is not a viable remedial action for this site. In comparison to Alternative 2, Alternative 3 is more difficult and more costly to implement and has lower short-term effectiveness. Alternative 2, which would enhance the active biological degradation of site VOCs, meets the NCP criteria and was selected as the preferred alternative for Site 11.

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
°C	degrees Celsius
CD	cyclodextrin
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN II	Comprehensive Long-Term Environmental Action Navy II
COPC	contaminant of potential concern
CT	central tendency
CTO	Contract Task Order
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DPT	Direct Push Technology
ERA	ecological risk assessment
ERH	electrical resistance heating
ERD	enhanced reductive dechlorination
ESTCP	Environmental Security Technology Certification Program
FS	Feasibility Study
ft	feet
FWES	Foster Wheeler Environmental Services
g	gram
HHRA	human health risk assessment
HRC®	Hydrogen Release Compound®
H_2	hydrogen
IAS	Initial Assessment Study
IDW	Investigation Derived Waste
IR	Installation Restoration
IRI	Interim Remedial Investigation
kg	kilogram
L	liter
LUCs	land use controls

MCL	maximum contaminant level
µg	micrograms
mg	milligrams
MIP	Membrane Interface Probe
NAB	Naval Amphibious Base
NACIP	Navy Assessment and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
O&M	operations and maintenance
OMB	Office of Management and Budget
PCP	pentachlorophenol
PRG	Preliminary Remediation Goals
PVC	polyvinyl chloride
RAO	remedial action objective
RGH	Rogers, Golden, and Halpern
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
RVS	Round 1 Verification Step
SARA	Superfund Amendments and Reauthorization Act
SERA	screening ecological risk assessment
SRI	Supplemental Remedial Investigation
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
TBC	to-be-considered
TCA	trichloroethane
TCE	trichloroethene
TOC	total organic carbon
TOD	total oxidant demand
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VFAs	volatile fatty acids
VOC	volatile organic compound
yr	year

SECTION 1

Introduction and Background

This report presents the Feasibility Study (FS) for Site 11, the former School of Music Plating Shop at Naval Amphibious Base (NAB) Little Creek. This FS report is prepared by CH2M HILL under the Naval Facilities Engineering Command (NAVFAC), Atlantic Division Comprehensive Long-Term Environmental Action Navy II (CLEAN II) Contract N62470-95-D-6007, Contract Task Order (CTO) 0159, for submittal to NAVFAC, the United States Environmental Protection Agency (USEPA), and the Virginia Department of Environmental Quality (VDEQ). The FS is prepared in accordance with the process outlined in the Navy's Installation Restoration (IR) Program, which is consistent with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA).

Previous investigations have identified a groundwater plume containing volatile organic compounds (VOCs) associated with the former School of Music Plating Shop and neutralization tank. The nature and extent of contamination and human health risk assessment (HHRA) are documented in the Site 11 Supplemental Remedial Investigation (SRI) report (CH2M HILL, June 2004) and the Site 11 Revised HHRA, SRI Addendum (CH2M HILL, January 2006). There are no unacceptable ecological risks identified at Site 11 (CH2M HILL, June 2000). Additional soil and groundwater sampling and analyses were completed in 2005 as part of development of this FS; results of the 2005 investigations are documented herein.

The objectives of this FS are to evaluate remedial alternatives to prevent unacceptable risk exposure to groundwater and reduce the concentration of VOCs in groundwater to levels that allow for unlimited use and unrestricted exposure at Site 11. The FS develops and evaluates remedial alternatives to meet the remedial action objective (RAO) and identifies applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria.

This FS report is composed of the following sections:

Figures and tables referenced within the text are provided at the end of the text. Appendices are provided at the end of the report.

1.1 Site Description and History

NAB Little Creek is primarily an industrial facility and provides logistic facilities and support services for local commands, organizations, home-ported ships, and other units to meet the amphibious warfare training requirements of the Armed Forces of the United States. In addition to industrial land-use, NAB Little Creek is also used for recreational, commercial, and residential purposes. The location of NAB Little Creek is shown in Figure 1-1.

The area surrounding the 2,215-acre NAB is low lying and relatively flat with several fresh water lakes. Chubb Lake, Lake Bradford, Little Creek Reservoir/Lake Smith, and Lake Whitehurst are located on, or adjacent to, the base. Little Creek Reservoir/Lake Smith, located south of the base, serves as a secondary drinking water supply for parts of the city of Norfolk. NAB Little Creek is bordered by three saltwater bodies: Little Creek Cove, Desert Cove, and Little Creek Channel, which connects the coves with the Chesapeake Bay. The Chesapeake Bay borders the facility to the north.

1.1.1 Site History

Site 11 is located in the eastern portion of the base, near the intersection of Seventh and E Streets (Figure 1-2). The site consisted of the plating shop (Building 3651), an in-ground concrete tank used to neutralize plating solutions, and its associated piping. The tank was approximately 10 feet (ft) east of the south corner of Building 3651. Use of the neutralization tank took place between 1964 and 1974. Small quantities of plating baths, acids, and lacquer strippers were disposed of down the sink in the plating shop which drains into the neutralization tank and eventually into the storm sewer system. Reportedly, 10 gallons of plating solutions were disposed in the shop sinks each year. There are no records of chlorinated solvents such as trichloroethene (TCE) being used at Site 11, however degreasing solvents such as TCE and 1,1,1-trichloroethane (TCA) have historically been associated with operations at similar plating shops.

The neutralization tank, piping, and surrounding soil were excavated in 1996 (Figure 1-2). Subsurface soil samples were taken from the excavation and groundwater samples were collected from the three existing monitoring wells to confirm the effectiveness of the removal action (Figure 1-3). Four VOCs were detected in groundwater above the maximum contaminant level (MCL). The maximum detected concentration of each VOC exceeding the MCL is: 490 microgram (μg)/liter (L) TCE, 340 μg/L 1,1,1,-TCA, 34 μg/L 1,1-dichloroethene (DCE), and 17 μg/L 1,1-dichloroethane (DCA).

1.1.2 Site Characteristics

The hydrogeologic setting at Site 11 includes the unconfined coastal plain sands and silts of the Columbia Aquifer that extends approximately 20 to 25 ft below ground surface (bgs). The water table ranges in depth from 5 to 7 ft bgs. The hydrogeology is depicted in cross-section on Figure 1-4. The Columbia Aquifer is underlain by a clay-confining unit (Yorktown Confining Unit) that ranges in thickness from 30 to 40 ft. The confined Yorktown Aquifer underlies the confining clay and extends to a depth of 280 ft in the area of NAB Little Creek (Meng and Harsh 1988). As evidence by the general absence of VOCs detected in the Yorktown Aquifer and the low vertical permeability of the confining clay (between

1.56×10^{-8} and 3.0×10^{-7} centimeters/second) there is little risk of contamination moving from the Columbia Aquifer to the Yorktown Aquifer.

Groundwater flow in the Columbia Aquifer near Site 11 is generally east to west, but is locally influenced by a sanitary sewer system paralleling Gator Boulevard (Figure 1-2), where groundwater flow immediately north of the sewer line is to the south and flow direction immediately south of the sewer line is to the north (CH2M HILL, June 2004). Groundwater gradients are relatively flat. The average groundwater flow velocity in the Columbia Aquifer at Site 11 has been calculated to be approximately 110 ft/year (yr). Groundwater flow in the Yorktown Aquifer is to the northwest, toward the Chesapeake Bay (CH2M HILL, June 2004).

1.2 Previous Investigations

A summary of previous investigations at NAB Little Creek is provided in Table 1-1. NAB Little Creek initiated environmental investigation efforts under the Navy Assessment and Control of Installation Pollutants (NACIP) Program by conducting an Initial Assessment Study (IAS) in 1984 followed by a Round 1 Verification Step (RVS) in 1986.

An Interim Remedial Investigation (IRI) was completed in 1991 and a Remedial Investigation (RI)/FS report was completed in 1993. Subsequent to the RI/FS, a decision document was issued in November 1994 (FWES, November 1994a), proposing removal of the neutralization tank, associated piping, and neighboring surface and subsurface soil. The neutralization tank, piping, and surrounding soil were excavated in 1996. An Interim Removal Action closeout report was completed in 1996 (IT Corporation, May 1996). The results of post-removal action sampling are documented in *Final Groundwater Monitoring Report, Sites 5 and 11, Naval Amphibious Base Little Creek, Virginia Beach, Virginia* (CH2M HILL, February 1998). Additional groundwater sampling was recommended to further define the extent of VOCs in groundwater.

Ecological Risk Assessment (ERA) 2000

A screening ecological risk assessment (SERA) for Site 11 was completed in June 2000 (CH2M HILL, June 2000). The SERA concluded potential ecological risks at Site 11 are negligible based on the lack of complete and significant exposure pathways, and no further action was recommended for ecological resources.

Delineation Investigations 2001-2003

A Membrane Interface Probe (MIP) investigation was conducted in 2001 to further characterize the extent of VOCs in groundwater. Direct-push samples for off-site laboratory analysis were collected to confirm the MIP results. The results indicated that there had not been significant degradation of TCE (CH2M HILL, June 2004).

An Environmental Security Technology Certification Program (ESTCP) funded pilot test was conducted at Site 11 in 2002 to evaluate the *in situ* removal of organic contaminants from groundwater through the injection and extraction of a cyclodextrin (CD) solution (Boving et al., 2003). Six wells were installed for this study and follow-up groundwater sampling was completed in January 2003. A second MIP investigation was conducted in September 2003 to further assess the efficacy of the CD solution on the groundwater at the site. The field activities and findings associated with these 2003 investigations are documented in Technical Memorandums *"Summary of Site 11 Cyclodextrin Pilot Study Post-Treatment Groundwater Sampling"*, NAB Little Creek, Virginia Beach Virginia (CH2M HILL, July 2003), and *"NAB Little Creek Sites 11, 11a, and 13 Membrane Interface Probe Investigation and Confirmation Sampling"* (CH2M HILL, November 2003).

Supplemental Remedial Investigation (SRI) 2004

A SRI was completed in 2004 that incorporated data from 1996 through 2001. The SRI identified three inorganic contaminants of potential concern (COPCs) in surface soil (iron, manganese, and thallium) and two inorganic COPCs in groundwater (iron and chromium). Additionally, one semi-volatile organic compound (SVOC) [pentachlorophenol (PCP)] and two chlorinated VOCs (TCE and 1,1-DCE) were identified as COPCs in groundwater. The SRI concluded that VOCs in groundwater are limited to the lower portion of the Columbia Aquifer in the area of the former plating shop neutralization tank and extend south beneath the School of Music building to Gator Boulevard.

The SRI HHRA was completed for Site 11 based on data collected in 1998 and 1999. Groundwater samples collected following the CD pilot study (2003 through 2005) indicated degradation of parent VOCs. To effectively evaluate remedial action alternatives in this FS, human health risks associated with exposure to VOCs in groundwater were reevaluated and are documented in the *Site 11 Revised HHRA SRI Addendum* (CH2M HILL, January 2006). Based on background concentrations and the calculated potential risk from central tendency (CT) exposures, the Navy in partnership with the VDEQ and USEPA determined there were no unacceptable human health risk associated with exposure to inorganic constituents in groundwater and soil at Site 11 (CH2M HILL, January 2006). PCP was retained as an SVOC COPC. A summary of the VOC COPCs posing potential unacceptable risk to be addressed by this FS are summarized in Table 1-2.

Vapor Intrusion Investigation 2005

To address potential vapor intrusion of VOCs from groundwater into the School of Music (Building 3602), a site visit was conducted and groundwater samples from the top of the water table aquifer and a water sample from the basement sump for VOC analyses were collected in May 2005. This effort concluded that there are limited pathways for soil gas to intrude into the building as the first floor was under a positive pressure relative to the basement mechanical room, and there were no VOCs detected in six of the eight shallow groundwater samples. Only chloromethane (1.7 μg/L) and TCE (6.3 μg/L) were detected at very low concentrations. There were no VOCs detected in the sample collected from the basement sump. VOC concentrations at the top of the water table are well below risk screening levels determined using the Johnson and Ettinger model. The vapor intrusion assessment concluded even in the event of conditions promoting vapor intrusion, concentrations of VOCs in groundwater will not represent unacceptable human health risks from vapor intrusion inside the School of Music building. Results are presented in *Vapor Intrusion Assessment, Site 11, Naval Amphibious Base Little Creek* (CH2M HILL, 2005; Appendix A).

Pre-Feasibility Study Investigations 2005

Groundwater sampling for VOC analysis was conducted at Site 11 in March 2005 to support evaluation of remedial action alternatives. Additional soil and groundwater sampling was completed in October 2005 to further support analysis of remedial action alternatives for the FS. The sampling protocol and results are provided in Appendix B.

Total VOC concentrations in groundwater samples collected from the Columbia Aquifer exceeded 100,000 µg/L in the area of the former neutralization tank. Figure 1-5 illustrates the total VOC concentrations in groundwater and identifies highest concentration source area. Although DNPL was not identified, individual VOC concentrations in soils in the source area exceeded 10,000 µg/kilogram (kg) at the top of the Yorktown Confining Unit; the greatest concentration was 25,000 µg/kg of TCE. In the lower portion of the Columbia Aquifer the maximum individual VOC concentration in soil was 600 µg/kg of cis-1,2-DCE. In the upper portion of the Columbia Aquifer the maximum individual VOC concentration in soil was 55 µg/kg of TCE.

Microbial analysis verified the presence of healthy microbial populations capable of biodegradation of chlorinated VOCs. Total oxidant demand (TOD) was analyzed using sodium persulfate as the oxidant. Results ranged from 1.9 to 3.7 gram (g)/kg of sodium persulfate in the lower portion of the Columbia Aquifer and 11 to greater than 19.5 g/kg of sodium persulfate in the Yorktown Confining Unit. These values were not unexpected based on the elevated concentrations of total organic carbon (TOC) in soil (Appendix B). Geotechnical analysis including soil characterization, grain size, moisture content, and porosity was also completed; the results are provided in Appendix B.

1.3 Nature and Extent of Contamination

The former Plating Shop neutralization tank was the source of VOCs in groundwater. The neutralization tank, associated piping, and surrounding soil have been removed. VOCs released from the former neutralization tank migrated into the subsurface and were further transported through the groundwater system via dissolution, advection, and dispersion. Groundwater flow is towards the south and southeast, and is influenced by a leaking sanitary sewer line along Gator Boulevard. The current groundwater infiltration rate is approximately 10 gallons per minute (CH2M HILL, June 2004). A detailed evaluation of the site conceptual model, including nature and extent, and contaminant fate and transport, is documented in the *Supplemental Remedial Investigation for Site 11* (CH2M HILL, June 2004).

Groundwater contamination at Site 11 includes a residual source area (sorbed mass and aqueous phase contaminants) and a down-gradient plume consisting predominantly of dissolved-phase contaminants (Figure 1-5). Residual dense non-aqueous phase liquid (DNAPL) may be indicated if dissolved phase concentrations are greater than or equal to 1% of the maximum aqueous solubility. Since the CD pilot test, no TCE or 1,1,1-TCA concentrations have been detected in groundwater samples above 1% of its maximum aqueous solubility. Because cis-1,2-DCE was never used at the site in pure form and has only been detected at concentrations of 1% of its maximum aqueous solubility following the CD pilot study, its presence is likely due to the degradation of TCE and not the presence of DNAPL.

TCE was detected at a concentration above its 1% of maximum solubility level (11,000 μg/L) in well LS11-MW5D once in 1998. Subsequently in 1999 and later, TCE concentrations in groundwater samples from this well were significantly below 11,000 μg/L. This suggests that only a dissolved phase plume is present in this area (i.e., no DNAPL). Based on these groundwater data and the site history, the area selected for source area remedial action consideration includes the area treated during the CD pilot test. This area is shown in Figure 1-5.

The target depth interval for the remedial action is the bottom 3 to 5 ft of the shallow surficial aquifer, just above the clay layer present at the site at approximately 21 to 23 ft bgs. Previous groundwater sampling has shown that the groundwater contamination is highly stratified, with the interval just above the clay containing the greatest concentrations of contaminants. Shallower groundwater contains much lower VOC concentrations.

Prior to implementation of a remedial action, the sanitary sewer intercepting groundwater flow will be repaired. Following repair of the sanitary sewer, remedial actions will not be implemented until the aquifer has re-equilibrated and an additional round of groundwater level gauging is conducted to verify groundwater velocity and direction. Based on these observations, the number and alignment of injection and monitoring wells may be modified.

SECTION 2

Remedial Action Objective (RAO) and Applicable or Relevant and Appropriate Requirements (ARARs)

This section discusses the NCP and CERCLA objectives, identifies the Site 11 RAO and ARARs for the remedial actions considered in this FS.

2.1 NCP and CERCLA Objectives

The NCP requires that the selected remedy meet the following:

- Each remedial action selected shall be protective of human health and the environment [40 Code of Federal Regulations (CFR) 300.430 (f)(ii)(A)].
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the Record of Decision (ROD) signature [40 CFR 300.430 (f)(ii)(B)].
- Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in §300.430(f)(1)(ii)(A) and (B). A remedy shall be cost-effective if its costs are proportional to its overall effectiveness.
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable [40 CFR 300.430 (f)(ii)(E)].

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment" (Section 121(d)(1)).
- Remedial actions in which treatment that "permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element are to be preferred" (Section 121(b)(1)). If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published (Section 121 (b)(1)(G)).
- The least-favored remedial actions are those that include "offsite transport and disposal of hazardous substances or contaminated materials without treatment" where practicable treatment technologies are available (Section 121(b)(1)).

- The selected remedy must comply with or attain the level of any standard, requirement, criteria, or limitation under Federal environmental law or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation (Section 121(d)(2)(A)).

2.2 Remedial Action Objective

The only media of concern at Site 11 is groundwater. No unacceptable ecological risks are identified at Site 11. Remedial actions are developed for consideration to ensure protection of human health and to cost-effectively minimize disruption to the Base Mission and existing facility operations.

The RAO for the protection of human health and the environment for Site 11 groundwater is:

- Reduce concentrations in groundwater to the maximum extent practicable and maintain land use controls until concentrations allow for unlimited use and unrestricted exposure at Site 11.

2.2.1 Development of Risk-Based Preliminary Remediation Goals (PRGs)

Preliminary Remediation Goals (PRGs) were developed for constituents with concentrations contributing appreciably to unacceptable risks and hazards from exposure to groundwater within Site 11. Based on the SRI HHRA (CH2M HILL, June 2004) and the Revised HHRA, SRI Addendum (CH2M HILL, January 2006), COPCs were identified as those constituents with cancer risks exceeding 10^{-4}, or hazard index exceeding 1. The COPCs include one SVOC (PCP) and 13 VOCs, and are identified in Table 1-2.

To achieve remedial action objectives for unlimited use and unrestricted exposure, remediation goals are established as the MCL to the extent practicable. Because there is no established MCL for 1,1-DCA, a PRG was calculated using the same exposure assumptions used in the human health risk assessment and equations from the *Risk Assessment Guidance for Superfund Volume 1, Part B* (USEPA, December 1991) (Appendix C). To achieve remedial action objectives for unlimited use and unrestricted exposure, remediation goals are established as the MCL to the extent practicable.

The remediation goals for Site 11 groundwater are presented in Table 2-1.

2.3 Applicable or Relevant and Appropriate Requirements (ARARs)

As required by Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and state environmental laws and state facility-siting laws, unless waivers are obtained. According to USEPA guidance, remedial actions should also be based on non-promulgated To-be-considered (TBC) criteria or guidelines if the ARARs do not address a particular situation.

ARARs are identified by the USEPA as either being applicable to a situation or relevant and appropriate to it.

"Applicable requirements" are standards and other environmental protection requirements of federal or state law dealing with a hazardous substance, pollutant, contaminant, action being taken, location, or other circumstance at a CERCLA site.

"Relevant and appropriate requirements" are standards and environmental protection criteria of federal or state law that, although not "applicable" to a hazardous substance, pollutant, contaminant, action being taken, location, or other circumstance, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. A requirement that is relevant and appropriate must be met as if it were applicable. TBC criteria are non-promulgated advisories or guidance issued by federal or state government that are not legally binding, and do not have the status of potential ARARs. TBCs are evaluated along with ARARs and may be implemented by USEPA when ARARs are not fully protective of human health and the environment.

Onsite CERCLA response actions must meet substantive requirements but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment. Administrative requirements implement the substantive requirements by prescribing procedures such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements such as permits.

Three classifications of requirements are defined by USEPA in the ARAR determination process: chemical-specific, location-specific, and action-specific. These classifications are described below. The remedial action alternatives developed in this FS were analyzed for compliance with the potential Federal and State ARARs, and are provided in Appendix D.

Chemical-specific ARARs are health or risk management-based numbers or methodologies that result in the establishment of numerical values for a given medium that would meet the NCP "threshold criterion" of overall protection of human health and the environment. These requirements generally set protective cleanup concentrations for the chemicals of concern in the designated media, or set safe concentrations of discharge for response activity. Federal and Commonwealth of Virginia chemical-specific regulations that have been reviewed are summarized in Appendix D.

Location-specific ARARs restrict response activities and media concentrations based on the characteristics of the surrounding environments. Location-specific ARARs may include restrictions on response actions within wetlands or floodplains, near locations of known endangered species, or on protected waterways. Federal and Commonwealth of Virginia location-specific regulations that have been reviewed are summarized in Appendix D.

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances. Federal and Commonwealth of Virginia action-specific ARARs that may affect the development and conceptual arrangement of response alternatives are summarized in Appendix D.

SECTION 3

Screening of Remedial Technologies and Identification of Remedial Alternatives

General response actions are broad responses, remedies, or technologies developed to meet site-specific RAO(s) and address COPCs, migration pathways, and exposure routes. The general response actions listed below have been identified for the remediation of Site 11:

- No Action
- *In situ* Treatment
- Land Use Controls
- Monitoring

The *No Action* response is included in accordance with the NCP to serve as a baseline for evaluation of the remedial actions.

In situ Treatment response actions are *in situ* methods of reducing the toxicity, mobility, or volume of contaminants in groundwater. Treatment technologies include biological and physical processes.

Land Use Controls (LUCs) consist of a number of alternatives that can be used alone or as part of another response action. LUCs include activities such as restricting groundwater use though land-use restrictions, deed restrictions, or access restrictions.

The *Monitoring* response action includes a groundwater sampling program to assess the behavior of contaminants over time, natural processes attenuating the contaminants, and performance of an active remediation.

Prior to implementing any alternative, the sanitary sewer line located south and east of Site 11 would be repaired. Following this repair, another round of groundwater samples, including water levels should be performed to confirm the extent of the plume, existing geochemical groundwater quality, baseline data and groundwater velocity and direction.

3.1 Screening of Remedial Technologies

Remediation of COPCs in groundwater at Site 11 is required to address potential unacceptable risks. Groundwater contamination to be addressed by the remedial alternatives consists of the "source" and the "plume." The source area at Site 11 is characterized by the highest groundwater concentrations and sorbed phase constituents. The plume area includes the entire area of groundwater contamination that consists predominantly of dissolved-phase constituents. The source and plume area at Site 11 are illustrated in Figure 1-5. The technologies were screened separately for the source and the plume to allow for the selection of the most appropriate technology for each area.

An initial review of the available technologies was completed; technologies that were considered unsuitable for the remedial action at Site 11 were screened out early in the process. This screening process incorporated the Navy's preference to select a remedy that would minimize impacts to current land use, and minimize use of technologies requiring the construction and prolonged (greater than one year) operation of *ex-situ* systems. The technologies excluded from further consideration include pump and treat, soil vapor extraction, and air sparging. Based on the effectiveness of the CD pilot study, further consideration was not given to co-solvent flushing. Technologies that would not effectively treat all COPCs (e.g., zero valent iron) were also excluded from further consideration. Furthermore, *in situ* chemical oxidation was screened out due to cost and technical impracticability associated with delivering enough oxidant to meet the elevated site TOD. The assessment conducted in 2005 (Appendix A) verified there is no concern for potential vapor intrusion at Site 11. Consequently, vapor intrusion is not anticipated to be a concern with the implementation of the alternatives provided in this FS, and associated vapor mitigation and monitoring was not evaluated.

Technologies that were retained for further consideration included those that compliment the existing reducing conditions and the naturally occurring biodegradation of VOCs. Enhanced reductive dechlorination (ERD) was selected for further evaluation for treatment of both the source and the plume. Electrical resistance heating (ERH) was also selected for further evaluation. However ERH was only evaluated as a treatment technology for the source area since it is not considered a cost effective technology for the treatment of dissolved phase VOC plumes.

3.2 Description of Remedial Alternatives

Three remedial alternatives were developed from the technologies retained following the screening process. These are:

Alternative 1 - No Action

Alternative 2 - Enhanced Reductive Dechlorination

Alternative 3 - Electrical Resistance Heating & Enhanced Reductive Dechlorination

With the exception of Alternative 1 (no action), each of the remedial alternatives evaluated requires groundwater monitoring and the implementation of LUCs to prevent unacceptable risk exposure. Monitoring and LUCs would be maintained until groundwater concentrations allow for unlimited use and unrestricted exposure, with five-year statutory reviews to ensure protection of human health and the environment.

3.2.1 Alternative 1 – No Action

Alternative 1 is the no-action alternative. Under this scenario, no remedial actions are taken at Site 11 and contaminants would remain in the groundwater at Site 11.

3.2.2 Alternative 2 – Enhanced Reductive Dechlorination (ERD)

Biological reductive dechlorination is a naturally-occurring, microbially-mediated, anaerobic process in which chlorine atoms on a parent VOC molecule are sequentially replaced with hydrogen. In the reductive dechlorination process, electrons are transferred from an electron donor source to the VOC compound, which functions as the electron receptor. Therefore, an external electron donor source is required for the reaction to occur. Potential electron donor sources include biodegradable organic co-contaminants, native organic matter, or substrates intentionally added to the subsurface. Deeply anaerobic (reducing) conditions are required for reductive dechlorination of many VOCs, and competing electron acceptors such as dissolved oxygen, nitrate, nitrite, manganese(IV), ferrous iron, and sulfate must be depleted.

The predominant parent COPCs at Site 11 are TCE and 1,1,1-TCA. The principal anaerobic biodegradation pathway for TCE is:

TCE → cis-1,2-DCE → vinyl chloride (VC) → ethene→ ethane

The transformation rate for each step varies but tends to become slower with progress along the breakdown sequence, often resulting in accumulation of 1,2-DCE and VC. Further breakdown from 1,2-DCE and VC to ethene varies and is based on site specific conditions.

1,1,1-TCA degrades biotically to 1,1-DCA and abiotically to 1,1-DCE. Following this step, the principal anaerobic biodegradation pathway is:

1,1-DCA → chloroethane → ethane

1,1-DCE → VC →ethene → ethane

Complete dechlorination of TCE and 1,1,1-TCA has been occurring and is expected to continue at Site 11.

Enhanced anaerobic bioremediation of VOCs is implemented by adding a suitable substrate (soluble or insoluble) to the subsurface. The introduced substrate serves multiple purposes: depletion of competing electron acceptors, creating strongly reducing conditions, and producing an electron donor source for reductive dechlorination.

The most commonly used insoluble substrates are Hydrogen Release Compound® (HRC®) and vegetable oil. Vegetable oil is injected as an emulsified liquid. Linoleic and other long chain fatty acids in the vegetable oil slowly solubilize in water over time and are broken down by native microorganisms to lower molecular weight fatty acids such as pyruvate and propionate. Ultimately, the oil degrades to form acetic acid and hydrogen. The hydrogen and dissolved organic carbon from the acetic acid are then available to support reductive dechlorination of chlorinated solvents. Vendors estimate that vegetable oil may serve as an electron donor for at least a year and as much as three years depending on site specific conditions, and are typically applied via direct push technology (DPT) points.

Soluble substrates include benzoate, lactate, acetate, propionate, butyrate, methanol, ethanol, sucrose, molasses, and hydrogen (H_2). These substrates are water soluble, degrade rapidly, and are transported with groundwater flow. Since these substrates degrade rapidly, they typically require more frequent injections than insoluble substrates and therefore are generally dispensed via permanent injection wells.

For the purpose of this FS conceptual design and cost estimate, sodium lactate, a widely-used and effective soluble substrate, was selected. Sodium lactate is available in 55 gallon drums or approximately 2000 gallon totes. It is typically delivered as a 60 % solution. The cost estimate was prepared assuming multiple injections over time to maintain the electron donor available for use by dechlorinating bacteria. The repeated substrate injections throughout each year of substrate injection also serves to increase subsurface mixing thereby enhancing substrate distribution which subsequently allows for increased degradation of COPCs. To minimize disruption of current land use, the use of a slow-release organic substrate (e.g., vegetable oil), which requires less frequent injections, may be substituted for lactate at the onset of the remedial action. However, reducing the number of injections minimizes subsurface mixing and may consequently increase the length of time the remedial action is implemented. If COPC degradation is not sufficient, use of the slow-release organic substrate should be replaced by use of a soluble substrate.

Source Treatment

For treating the source area, an injection well array, with wells spaced on no more than approximately 15 ft centers, was selected. The existing injection wells (LS11-MW23D, LS11-MW24D, LS11-MW25D, LS11-MW26D, LS11-MW27D, LS11-MW28D, LS11-MW29D, and LS11-MW30D), which were installed as part of the CD injection pilot test, are suitable for substrate injection. These existing wells are constructed of 4 inch-diameter polyvinyl chloride (PVC) with 5 ft of well screens. Because these wells provide adequate coverage of the target source area, no new injection wells are considered necessary.

As shown on Figure 3-1, two new monitoring wells are proposed to monitor the performance of the ERD process in the source area. One well is located within the target injection zone and will measure changes in groundwater quality that occur within the injection zone. The other performance monitoring well is located slightly downgradient of the injection zone to measure changes in groundwater quality migrating from the source zone. In addition to these monitoring wells, periodic monitoring of wells LS11-MW5S and LS11-MW5D is recommended.

Plume Treatment

TCE concentrations collected from monitoring well LS11-MW10D are less than 500 µg/L, but are greater than concentrations detected in other portions of the downgradient plume. Therefore, additional treatment in this location was selected to expedite cleanup of this localized area. To target this area, two injection wells will be installed approximately 10 ft upgradient of well LS11-MW10D and well LS11-MW10D will be monitored to evaluate the performance of the ERD process in this area.

A biobarrier, consisting of 23 injection wells spaced at approximately 15 ft centers and located near the downgradient edge of the plume, was selected based on current groundwater flow conditions (Figure 3-1). Following repair of the leaky sanitary sewer and stabilization of groundwater flow, groundwater flow will be re-evaluated for effective placement of the biobarrier. It is anticipated the injection wells in the biobarrier will be installed at least 15 to 20 ft from the parking lot and road. This will allow space to install three downgradient performance monitoring wells in the unpaved area. In addition to these new wells, well LS11-MW09 will be monitored to evaluate system performance.

Well Construction

New monitoring wells will be constructed of 2 inch-diameter PVC with 5 ft well screens, whereas new injection wells will be constructed of 2 inch diameter PVC, with 5 ft continuous slot (wire-wrapped) well screens. The wells should be constructed to the top of the Yorktown Confining Unit which is located approximately 23 ft bgs. Soil cores will be collected via DPT along the proposed biobarrier alignment to ensure that the correct depth is established prior to injection well installation. To substantiate the proposed biobarrier location and width, groundwater samples will be collected from DPT locations and analyzed to confirm the presence of VOCs

Substrate Injection and Performance Monitoring

For the source area and biobarrier injection wells, the target volume of injectate for each injection event is the amount necessary to achieve a radius of influence (ROI) equal to half of the distance between each well. For a 5 ft well screen, a target radius of influence of 7.5 ft, and an assumed effective porosity of 0.20, the target injectate volume per well is approximately 1,320 gallons.

The injectate solution should initially have a lactate concentration of 1% (10,000 milligrams (mg)/L). As the treatment progresses and the ERD system matures, this concentration may increase or decrease based on the system response and frequency of injection. It is difficult to estimate the treatment time required to achieve adequate reduction in VOCs to allow active remediation to cease. For the purpose of this FS it was assumed that the source and plume would receive six substrate injections per year during year zero of the remedial action. During years one through seven, the source would receive four injections per year, while the plume would receive three injections per year. It is assumed that the source will be adequately treated after year seven and during years eight through 14, only the plume would require treatment (at a frequency of 3 injections per year).

Sampling and analysis of the ERD process is important to ensure that effective and optimal conditions are established for the microorganisms. A proposed performance monitoring schedule and analyte list is provided in Table 3-1. Additionally, groundwater monitoring will be required to continue after active remediation ceases if VOC concentrations in groundwater continue to exceed MCLs.

3.2.3 Alternative 3 – Electrical Resistance Heating (ERH) & Enhanced Reductive Dechlorination (ERD)

In situ thermal treatment (electrical resistive heating or conductive heating) is an applicable technology for treatment of high concentrations of dissolved- and sorbed-phase VOCs. This technology involves the active heating of the subsurface to force volatile contaminants into the vapor phase where they can vent to the ground surface or be removed by an active vapor extraction system for ex-situ treatment. Thermal treatments also typically vaporize some or all of the pore water within an aquifer to steam, which either carries or flushes contaminants to a vapor extraction point. In addition to the physical destruction of VOCs, thermal treatment increases microbial activity of dechlorinating bacteria, which enhance the naturally occurring biological degradation of VOCs.

ERH involves the placement of a network of electrodes in the subsurface and the application of current through the subsurface. Resistance to current flow within the subsurface produces heat. ERH is typically used to raise subsurface temperatures to the boiling point of the contaminant, causing partial vaporization of the contaminant within the treatment zone. Steam generated by this process acts as a contaminant carrier and migrates upward to the vadose zone, where co-located vapor extraction wells remove the steam for further treatment at an aboveground treatment system. Because this process relies on elevating the temperature of water, ERH is only capable of volatilizing constituents with boiling points of 100 °C or less.

Conductive heating involves the application of a network of direct-heating probes installed within subsurface wells. Heat from the probes, typically installed within a well also used for vapor extraction, is transmitted through the subsurface by conductance. Conductive heating is typically used to raise subsurface temperatures significantly above the water boiling point, forcing the complete vaporization of all pore water near the heating probes. Vaporized steam can then be extracted at depth without requiring steam to migrate to the vadose zone.

For the purpose of the FS, it is assumed that the source area is to be treated using ERH followed by polishing and plume treatment with ERD (Figure 3-2). With the exception of PCP, all site COPCs have a boiling point of less than 100 °C and can be treated via ERH. Although PCP has a boiling point of greater than 100 °C, PCP was detected only once in a sample collected in 1999 from monitoring well LS11-MW04D and this sample location is not the area to be remediated by thermal treatment. Additionally, PCP is reductively dechlorinated by anaerobic bacteria, and hence will be treated by ERD.

The cost estimate for the ERH system and operation was provided by a vendor that specializes in the construction of ERH systems. However, if ERH is selected as the source treatment technology for this site, the ultimate design of the system will be completed by the vendor awarded the work. The cost estimate for Alternative 3 was based on the following assumptions: the cost estimate prepared by the vendor was representative of the cost to implement ERH in the designated source area; the source area and plume area are comparable in size and location as those designated for Alternative 2; and the remainder of the plume, including the elevated concentrations at monitoring well LS11-MW10D would be treated and monitored using the approach described for Alternative 2 (e.g., biobarriers, injection, and monitoring wells).

Because of the thermal stress imposed in the source area, the existing PVC wells located within the thermal treatment area will need to be abandoned and replaced with stainless steel wells. The new well should be placed as close as possible to the existing wells and their screened intervals should be the same as the existing wells so that the analytical data from these new wells is comparable to the previous sampling data. Also, the new wells should be constructed with continuous slot well screens since they will be used as injection wells for the ERD polishing after ERH is completed.

For cost estimating purposes, it was assumed that the ERH system would operate for four months. However, residual CD remaining in the subsurface from the CD pilot study may reduce the rate at which COPCs volatilize, thereby resulting in a longer ERH operating period. During the period in which the ERH system is operating, groundwater sampling would be completed after the second and third month of operation, and twice during the fourth month of operation to monitor the effectiveness of the remedy. If groundwater concentrations are sufficiently reduced, operation may cease. However, if COPC concentrations remain elevated or rebound the ERH system will continue to operate. Based on the effectiveness of this remedy and previous experience it is not anticipated that this system will be required to operate for greater than nine months.

Since ERH may not reduce concentrations to MCLs, ERD will be used as a polishing step in the source area. For cost estimating purposes, it was assumed that the ERH system would operate for four months followed by two subsequent source area ERD injections in year zero. It was assumed that source area polishing would be necessary for three more years (at four injections per year). Similar to Alternative 2, it was assumed that the plume would receive six injections during year zero and three injections per year during years one through 14. It was assumed that monitoring would be completed as described for Alternative 2. However to meet the ERH performance monitoring schedule, one additional sampling round would be completed for VOCs, TOC, methane, ethane, ethane, and volatile fatty acids (VFAs) during year zero. The monitoring schedule for Alternative 3 is provided in Table 3-2.

SECTION 4

Evaluation of Remedial Alternatives

Remedial alternatives, including the no action alternative, were developed for Site 11 to reduce concentrations of VOCs in groundwater to meet the RAO.

4.1 Evaluation Criteria

The remedial alternatives that have been developed for Site 11 are evaluated based on nine NCP criteria. Each alternative is evaluated and with respect to each NCP criterion and one another. The purpose of this comparative analysis is to identify the relative advantages and disadvantages of each alternative and identify the best balance of trade offs for remedy selection. The Navy developed this FS in partnership with the EPA and VDEQ, and therefore concurs with the comparative analysis and selection of a preferred remedial alternative. Community acceptance for selection of a preferred remedial alternative will be addressed in the ROD for Site 11. The nine NCP criteria are:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

For the cost analysis, the expenditures required to complete each remedial action are estimated in terms of both capital and annual operations and maintenance (O&M) costs. All expenditures for Year 0 were included as capital costs. Assumptions associated with present worth calculations include a discount rate of 3.1 percent (Office of Management and Budget (OMB), January 2005), cost estimates in the planning years in constant dollars, and a period of performance that would vary depending on the activity, but would not exceed 30 years.

The cost estimate for each alternative is provided as an order of magnitude cost estimate and were estimated from comparable projects (e.g., engineering experience) and quotations. The estimate has been prepared without equipment specifications, layout, design, or engineering calculations. The expected level of accuracy is +50 percent to -30 percent. The cost estimates are in 2005 dollars and are based on the current conceptual design. Cost estimates for Alternatives 2 and 3 are provided in Appendix E.

4.2 Detailed Analysis of Remedial Alternatives

A summary of the detailed analysis of each remedial alternative is presented below and summarized in Table 4-1.

4.2.1 Alternative 1—No Action

Evaluating a "no action" alternative is required by the NCP. Under this alternative, no further effort or resources would be expended to remediate contaminated groundwater at Site 11. Because contaminated media would be left on the site, a review of site conditions would be required every 5 years. Alternative 1 serves as the baseline against which the other alternatives are judged.

Overall Protection of Human Health and the Environment

The No Action alternative is not protective of human health and the environment. This alternative does not provide any means to prevent exposure to contaminated groundwater or measures to reduce contamination to acceptable levels that would allow unlimited use and unrestricted exposure.

Compliance with ARARs

VOC concentrations in groundwater exceed MCLs. The No Action Alternative does not include measures to reduce VOC concentrations; therefore Alternative 1 does not comply with chemical-specific ARARs. There are no location- or action-specific ARARs for this alternative because no remedial actions would be undertaken.

Long-Term Effectiveness and Permanence

Although groundwater sampling at Site 11 indicates VOCs are undergoing reductive dechlorination, with no action to enhance this process it is uncertain if the natural dechlorination could reduce concentrations to levels that would allow unlimited use and unrestricted exposure, and the time frame for natural dechlorination is considered unacceptable. Furthermore, LUCs would not be in place to prevent exposure to COPCs. Therefore the adequacy and reliability of this alternative is very low rendering Alternative 1 ineffective over the long term.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 1 has no feature that would act to reduce toxicity, mobility, or volume through treatment. Because no remedial actions would be undertaken, reduction of toxicity, mobility, and volume would only gradually occur as a result of natural processes.

Short-Term Effectiveness

There is no construction associated with this Alternative 1, so there are no adverse short-term impacts on workers, the community, or the environment.

Implementability

There are no issues concerning technical implementation of No Action.

Cost

Taking no action would require no capital expenditure.

4.2.2 Alternative 2: ERD

Alternative 2 involves implementation of ERD technology for treatment within the source and plume areas, post-treatment groundwater monitoring, and LUCs in the form of land and groundwater use restrictions.

Overall Protection of Human Health and the Environment

Alternative 2 is protective of human health and the environment. This alternative would actively treat COPCs and prevent human exposure through the use of LUCs during the implementation of the remedy until the RAO is met. The use of the biobarrier would also prevent or minimize the migration of COPC concentrations exceeding MCLs into currently unaffected media.

Compliance with ARARs

Alternative 2 would comply with chemical-, location-, and action-specific ARARs. Injection of substrate would enhance naturally occurring biological degradation processes to reduce VOC concentrations in groundwater, and is expected to comply with chemical-specific ARARs. The substantive requirements associated with injection and the storage, analysis, and disposal of waste generated during implementation of this alternative would be met. Therefore this alternative is expected to comply with location- and action-specific ARARs. Appendix D contains a detailed evaluation of ARARs for Alternative 2.

Long-Term Effectiveness and Permanence

Alternative 2 would effectively reduce concentrations of VOCs in groundwater to unlimited use and unrestricted exposure. Naturally occurring degradation processes would be accelerated by injecting a fermentable organic substrate to stimulate native microbes to degrade chlorinated solvents. In addition to source treatment, a biobarrier would be installed along the downgradient edge of the plume. Following the termination of the substrate injection activities, the aquifer would be conditioned for continued degradation of VOCs. Consequently, once adequately treated, VOC concentrations would remain below MCLs assuming that any source material is removed and no external source area is present.

LUCs and 5-year reviews would be implemented until levels allow for unlimited use and unrestricted exposure. VOCs would be removed through source treatment, plume treatment, and the installation of a downgradient biobarrier thereby reducing risk associated with migration of groundwater.

LUCs are expected to be adequate and reliable, and a groundwater monitoring program would be implemented to substantiate the effectiveness of the remedial action through tracking groundwater quality COPC over time.

Reduction of Toxicity, Mobility, and Volume through Treatment

Implementation of ERD would reduce the toxicity, mobility and volume of the VOCs in the source area and plume. Natural processes are expected to occur at an accelerated rate to degrade the remaining dissolved phase COPCs.

Short-Term Effectiveness

Alternative 2 requires the initial installation of injection and monitoring wells and regularly scheduled injections and groundwater monitoring throughout the life of this remedial action. Investigation derived waste (IDW) requiring disposal would be generated during well installation and during groundwater monitoring. IDW would be containerized and temporarily stored on-site prior to disposal at an approved facility. NAB Little Creek maintains a temporary storage area sufficient to accommodate the small volume of waste generated during the implementation of this alternative. Health and safety precautions would be required to protect workers and the community during drilling, transport and storage of IDW, and throughout subsequent substrate injections. Since ERD is an *in situ* technology, impacts to the community, workers and the environment are minimized.

Implementability

Technical Implementability and Availability of Services and Materials

ERD is a proven technology in which the addition of substrate to the subsurface provides the necessary conditions for dechlorinating bacteria to degrade VOCs. The previous investigations confirmed abundant populations of dechlorinating bacteria (Appendix B), thereby reducing uncertainty associated with this alternative.

The installation of the injection and monitoring wells is straightforward and can be accomplished by an experienced environmental drilling firm. The subsequent substrate injections follow a basic procedure that can be accomplished with relative ease. Well locations have been selected to maximize the effectiveness of this alternative while minimizing disturbance to the site. Nevertheless, disruption to existing land use (parking lot, access to Building 3602, and landscaped areas) would occur as the wells are installed and during injection and groundwater monitoring. The management of IDW generated during well installation, substrate injection, and groundwater monitoring is routinely and easily implemented.

The effectiveness of ERD would be monitored by analyzing groundwater geochemistry, the decrease in parent compounds, and presence of daughter products caused by biological degradation of the parent compound. Groundwater samples collected from up-gradient, mid-gradient, down-gradient, and side-gradient wells would provide data needed to monitor changes in VOC concentrations and plume size and location.

Administrative Implementability

Long-term administrative resources for implementation of LUCs and annual reviews would also be required, and can easily be implemented throughout the duration of this alternative, which is assumed to be 30 years.

Cost

The present value cost for Alternative 2 is $2,399,000 (Appendix E). The capital cost associated with Alternative 2 is $499,000 and includes well installation, the first year (Year 0) of substrate injection, sampling, reporting, and the cost incurred for the implementation of LUCs. Annual operating costs include substrate injection, sampling, annual site inspections, and associated reporting. These costs are expected to be incurred through Year 14. Annual costs are greater during Year 1-7 due to an additional injection (per year) in the source zone.

The cost associated with the 5-year reviews is presented as periodic costs incurred every 5 years. Long term monitoring costs include sampling to monitor the effectiveness of the remedy, annual site inspections, and the reporting associated with these activities. Long-term monitoring costs are provided through year 30.

As described in Section 3.2, this FS assumes sodium lactate would be used as the injectate for this alternative. Accordingly, the cost for this alternative is estimated using the cost to purchase sodium lactate as well as the cost for the injection procedures and schedules associated with the use of sodium lactate. However, a variety of other substrates are available and the actual cost to implement ERD would be dependent upon the substrate cost, the number of annual injections, and the effectiveness of the substrate that is ultimately selected.

Because of the uncertainty associated with the time required to reach the RAO, a conservative number of years for injection was used to estimate the cost of this alternative. The sampling scheme associated with the implementation of this alternative would provide a mechanism to evaluate the effectiveness of the remedy. An extension of the injection schedule may be required if the VOC concentrations are not adequately reduced, thereby causing a higher cost for the implementation of this alternative. Conversely, the number of injection may be reduced if VOCs continue to attenuate at an acceptable rate without the further addition of substrate.

4.2.3 Alternative 3: ERH and ERD

Alternative 3 involves implementation of ERH for treatment of the source area, ERD for a polishing step following ERH source treatment, and ERD treatment for the plume. The ERH system is targeted to accelerate mass reduction of VOCs in the source zone, and ERH and ERD are expected to increase naturally occurring biological degradation processes to further reduce VOC concentrations in groundwater. This alternative includes post treatment groundwater monitoring and LUCs in the form of land and groundwater use restrictions.

Overall Protection of Human Health and the Environment

Alternative 3 is protective of human health and the environment. This alternative would actively treat COPCs and prevent human exposure through the use of LUCs during the implementation of the remedy until the RAO is met ensuring protection of human health and the environment. The use of ERH would provide expedited mass reduction in the source area. The use of the biobarrier would also minimize the migration of COPCs in groundwater into unaffected media.

Compliance with ARARs

Alternative 3 is expected to comply with chemical-, location-, and action-specific ARARs. A system would be constructed to treat vapors generated during ERH operation. Alternative 3 is expected to comply with chemical-specific ARARs. The substantive requirements associated with injection and the storage, analysis, and disposal of IDW generated during implementation of this alternative would be met. Therefore this alternative is expected to comply with location- and action-specific ARARs. Appendix D contains a detailed evaluation of ARARs for Alternative 3.

Long-Term Effectiveness and Permanence

Alternative 3 would effectively reduce concentrations of VOCs in groundwater to unlimited use and unrestricted exposure. The increase in subsurface temperature caused by the operation of the ERH system and the injection of substrate would stimulate the native dechlorinating microbial populations thereby accelerating the naturally occurring degradation processes. Additionally, the installation of the biobarrier along the downgradient edge of the plume would serve as a mechanism to promote continued degradation of the plume. In conjunction with the implementation of this alternative, the anaerobic conditions present at Site 11 would provide for continued degradation of VOCs following the completion of the ERH operation and substrate injections. Therefore, once adequately treated, VOC concentrations would remain below MCLs assuming that any source material is removed and no external source area is present.

LUCs and 5-year reviews would be implemented until levels allow for unlimited use and unrestricted exposure. ERH would expedite mass reduction of VOCs in the source area and the injection of substrate would enhance biological degradation of VOCs in the plume thereby mitigating risk associated with the migration of VOCs to currently unaffected media.

LUCs are expected to be adequate and reliable, and a groundwater monitoring program would be implemented to substantiate the effectiveness of the remedial action through tracking groundwater quality and COPC concentrations over time.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 3 would provide a reduction of VOC toxicity, mobility, and volume in the source and plume through enhanced (physical and biological) degradation of VOC COPCs.

Short-Term Effectiveness

Construction activities for the implementation of Alternative 3 include the abandonment of monitoring wells in the source zone, the initial installation of injection and monitoring wells in the source zone and plume, and the installation of an ERH system in the source area. Additionally, this alternative requires the maintenance of the ERH system during ERH operation and regularly scheduled injections and groundwater monitoring events. IDW requiring disposal would be generated during well abandonment, well installation, ERH installation, and during groundwater monitoring. IDW would be containerized and temporarily stored on-site prior to disposal at an approved facility.

Health and safety precautions would be required to protect workers and the community during drilling, ERH operation, transport and storage of IDW, and throughout subsequent substrate injections. Since ERD is an *in situ* technology, impacts to the community, works and the environment are minimized. However, ERH contains *ex-situ* components including the power control system, vapor recovery and treatment system, and electrodes. Precautions would be necessary to minimize impacts to the community, environment, and the operation of the facility. Additionally, engineering controls would be constructed to prevent exposure to high voltages.

Implementability

Technical Implementability and Availability of Services and Materials

ERH is a proven technology capable of providing expedited mass reduction. As a result of the increase in subsurface temperatures, VOCs are physically degraded and populations of dechlorinating bacteria are stimulated, providing biological degradation of VOCs. The CD remaining in the subsurface following the pilot study contributes to the anaerobic conditions, thereby providing a suitable habit for dechlorinating bacteria. However, it is unknown how the CD would affect the volatilization of COPCs and the ERH system may require a longer than anticipated period of operation. ERD is also a proven technology in which the addition of substrate to the subsurface provides the necessary conditions for dechlorinating bacteria to degrade VOCs. Results from microbial analysis confirmed abundant populations of dechlorinating bacteria (Appendix B), thereby reducing uncertainty associated with this alternative.

The use of an ERH system requires PVC wells within the ERH treatment area be abandoned and replaced with stainless steel wells capable of withstanding the heat generated during operation. The design and construction of the system should be completed by an experienced vendor familiar with this type of thermal treatment. Following construction, the ERH system is anticipated to operate for approximately four months. During this time, the system would require monitoring and upkeep of the vapor recovery system. Since this system includes *ex-situ* components, impact to daily use of the site can not be avoided during system operation. For instance engineering controls would be required to prevent exposure to high voltages and to the power control system. However, to the greatest extent possible, the system would be designed with the intent to minimize impacts to the use of the site.

The abandonment and installation of the injection and monitoring wells is straightforward and can be accomplished by an experienced environmental drilling firm. The subsequent substrate injections follow a basic procedure that can accomplished with relative ease. Well locations have been selected to maximize the effectiveness of this alternative while minimizing disturbance to the site. Nevertheless, the use of some areas of the site would be temporarily impeded during well abandonment and installation, substrate injection, and groundwater monitoring.

IDW generated during well installation, substrate injection, and groundwater monitoring would be containerized and temporarily stored on-site prior to disposal in an approved facility. NAB Little Creek routinely manages IDW and maintains a temporary storage area sufficient to accommodate the small volume of waste generated during the implementation of this alternative.

The effectiveness of ERH can be measured by the overall decrease in COCs in the source area, which can be determined by groundwater monitoring throughout and subsequent to the operation of the ERH system. The effectiveness of ERD can be monitored by analyzing groundwater geochemistry, the decrease in parent compounds, and presence of daughter products caused by biological degradation of the parent compound. Groundwater samples collected from up-gradient, mid-gradient, down-gradient, and side-gradient wells would provide data needed to monitor changes in VOC concentrations and plume size and location.

Administrative Implementability

Long-term administrative resources for implementation of LUCs and annual reviews would also be required throughout the assumed 30-year duration of this alternative.

Cost

The present value cost for Alternative 3 is $2,841,000 (Appendix E). The capital cost associated with Alternative 2 is $1,047,000 and includes PVC well abandonment in the source zone followed by stainless steel well installation in the source zone, PVC well installation in the plume, ERH construction and operation, the first year (Year 0) of substrate injection, sampling, reporting, and the cost incurred for the implementation of LUCs. Annual operating costs include substrate injection, sampling, annual site inspections, and associated reporting. These costs are expected to be incurred through Year 14. Annual costs are greater during Year 1-3 due to an additional injection (per year) in the source zone. The cost associated with the 5-year reviews is presented as periodic costs incurred every 5 years. Long term monitoring costs include sampling to monitor the effectiveness of the remedy, annual site inspections, and the reporting associated with these activities. Long-term monitoring costs are provided through year 30.

A vendor quote was used to estimate the cost to construct and operate the ERH system. This cost may vary based on the actual vendor selected. As described in Section 3.2, this FS assumes sodium lactate would be used as the injectate for the ERD portion of this alternative. Accordingly, the cost for ERD is estimated using the cost to purchase sodium lactate as well as the cost for the injection procedures and schedules associated with the use of sodium lactate. However, a variety of other substrates are available and the actual cost to implement ERD would be dependent upon the substrate cost, the number of annual injections, and the effectiveness of the substrate that is ultimately selected.

Because of the uncertainty associated with the time required to reach the RAO, a conservative number of years for injection was used to estimate the cost of this alternative. The sampling scheme associated with the implementation of this alternative would provide a mechanism to evaluate the effectiveness of the remedy. An extension of the injection schedule may be required if the VOC concentrations are not adequately reduced, thereby causing a higher cost for the implementation of this alternative. Conversely, the number of injection may be reduced if VOCs continue to attenuate at an acceptable rate without the further addition of substrate.

4.3 Comparative Analysis of Remedial Alternatives

This section provides a comparison analysis to evaluate the relative performance of each alternative in relation to each other and the NCP criteria. The purpose of this analysis is to identify the advantages and disadvantages of each alternative relative to one another. A qualitative comparative analysis employed a ranking system of 1, 3, and 5, with 1 being the lowest valued metric and 5 being the highest. The results of the ranking for each alternative are included in Table 4-2.

Alternative 1, no action, is easily implemented, with no concerns for short term effectiveness and no associate cost. However, Alternative 1 does not provide protection of human health and the environment, does not comply with ARARs, is not effective in the long term, and does not reduce toxicity, mobility or volume through treatment. Alternative 1 is serves only as a baseline for the comparative analysis.

4.3.1 Overall Protection of Human Health and the Environment

The overall assessment of protection draws on the assessments of long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Alternatives 2 and 3 are both protective of human health and the environment and are comparable in their evaluation against long-term effectiveness and permanence and compliance with ARARs. However, as a result of the additional construction associated with the ERH and the *ex-situ* component of Alternative 3, Alternative 2 has greater short term effectiveness, and is therefore the most protective alternative evaluated.

4.3.2 Compliance with ARARs

Alternative 2 and 3 are expected to comply with ARARs. Since vapors extracted during ERH operation would require treatment, Alternative 3 includes additional ARARs. However, a vapor recovery system is incorporated in to the design and cost of this alternative, and would comply with ARARs. Appendix D contains a detailed evaluation of ARARs for Alternatives 2 and 3.

4.3.3 Long-Term Effectiveness and Permanence

Alternatives 2 and 3 would effectively reduce concentrations of VOCs in groundwater to unlimited use and unrestricted exposure. The use of ERH in the source zone is expected to increase the rate of mass reduction in the source zone, thereby decreasing the number of substrate injections in the source zone. Plume treatment with ERD, monitoring, and LUCs, are similar for Alternatives 2 and 3. Therefore, these alternatives are considered equally effective in achieving long-term effectiveness.

4.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 2 and 3 are similar in their use of substrate to enhance naturally occurring reductive dechlorination. However, Alternative 3 is most effective in achieving this criterion since it includes the use of ERH as source treatment to expedite mass reduction of VOCs in the source area.

4.3.5 Short-Term Effectiveness

The short-term effectiveness associated with Alternatives 2 and 3 are similar with respect to the implementation of ERD. Alternative 3 however, requires the replacement of wells and the construction and maintenance of an ERH system. Additionally, since there is an *ex-situ* component associated with ERH, there is additional potential for worker, community, and environmental exposure. Therefore Alternative 2 provides the greatest short-term effectiveness.

4.3.6 Implementability

The implementability associated with Alternative 2 and the ERD component of Alternative 3 is similar, with the exception that Alternative 3 requires wells located in the source area are replaced. Since Alternative 3 includes the construction, operation, and maintenance of an

ERH system, disruption of existing land use (parking, building access, and landscaped areas) in the vicinity of the School of Music, and difficulty of implementation is greater with Alternative 3. Alternative 2 is therefore easier to implement than Alternative 3.

4.3.7 Cost

The cost estimate for Alternatives 2 and 3 are provided in Appendix E. The use of ERH reduces the number of substrate injections in the source area, and therefore reduces annual injection costs during years three through seven. Nonetheless, the cost associated with replacing wells in the source area and the construction, operation, and maintenance of the ERH system for Alternative 3, renders Alternative 2 the most cost effective alternative.

SECTION 5

Rationale for the Preferred Alternative

The detailed evaluation (Section 4.2) followed by the comparative analysis (Section 4.3) of the remedial alternatives provided the basis for identifying the preferred alternative. Alternative 1 does not meet the statutory requirements of the NCP and is not a viable remedial action for this site. While the ERH component of Alternative 3 allows for expedited mass removal of the source area, this benefit does not outweigh the cost, greater difficulty associated with implementation, and lower short-term effectiveness associated with increased exposure to workers, the community, and the environment during construction, operation, and maintenance of the ERH system. The balance of trade-offs in the comparative analysis is illustrated in Table 4-2 and identifies Alternative 2 as the preferred alternative. In comparison to Alternative 3, Alternative 2 is protective of human health and the environment, complies with ARARs, is effective in the short- and long-term, reduces toxicity, mobility, and volume through treatment, is readily implemented, and is cost effective. Since, this site contains the anaerobic conditions necessary for reductive dechlorination the implementation of Alternative 2 would serve to enhance the biological degradation COPCs that is actively occurring at Site 11.

SECTION 6

References

Boving, T.B, J.E. McCray, W.J. Blanford, M.L. Brusseau, University of Rhode Island, Colorado School of Mines, University of Texas at San Antonio, and University of Arizona. 2003. *Cyclodextrin Enhanced In situ Removal of Organic Contaminants from Groundwater at Department of Defense Sites.*

CH2M HILL. October 1986. *Round 1 Verification Step (RVS). NAB Little Creek, Virginia Beach, Virginia.*

CH2M HILL. February 1998. *Final Groundwater Monitoring Report, Sites 5 and 11, Naval Amphibious Base Little Creek, Virginia Beach, Virginia.*

CH2M HILL. June 2000. *Final Screening Ecological Risk Assessment for IR Sites 5, 7, 9, 10, 11, 12, 13, and 16 and SWMU 3, NAB Little Creek, Virginia Beach, Virginia.*

CH2M HILL. December 2000. *Final Background Investigation for Naval Amphibious Base Little Creek, Virginia Beach, Virginia.*

CH2M HILL. July 2003. *Summary of Site 11 Cyclodextrin Pilot Study Post-Treatment Groundwater Sampling. NAB Little Creek, Virginia Beach, Virginia.*

CH2M HILL. November 2003. *NAB Little Creek Sites 11, 11a, and 13 Membrane Interface Probe Investigation and Confirmation Sampling, Virginia Beach, Virginia.*

CH2M HILL. June 2004. *Final Supplemental Remedial Investigation for Site 11 - School of Music Plating Shop Naval Amphibious Base Little Creek, Virginia Beach, Virginia.*

CH2M HILL. January 2006. *Draft Site 11 Revised HHRA SRI Addendum. Naval Amphibious Base Little Creek, Virginia Beach, Virginia.*

Ebasco Environmental Consultants. November 1991. *Draft Final Interim Remedial Investigation. NAB Little Creek, Virginia Beach, Virginia.*

FWES. November 1994a. *Final Decision Document. School of Music Plating Shop. NAB Little Creek, Virginia Beach, Virginia*

Foster Wheeler Environmental Services (FWES). November 1994b. *Remedial Investigation/Feasibility Study (RI/FS) for Sites 7 and 9-13. NAB Little Creek, Virginia Beach, Virginia.*

IT Corporation. May 1996. *Interim Removal Action. Final Closeout Report. Site 11 School of Music Plating Shop. Naval Amphibious Base Little Creek, Norfolk, Virginia.*

Meng, A. A. III and Harsh, J. F. 1988. *Hydrogeologic Framework of the Virginia Coastal Plain. RASA. United States Geological Survey Professional Paper 1404-C.*

Office of Management and Budget (OMB). January 2005. Circular No. A-94, Appendix C, Revised. http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

Rodgers, Golden, and Halpern (RGH). December 1984. *Initial Assessment Study (IAS). NAB Little Creek, Virginia Beach, Virginia.*

USEPA. December 1991. *Risk Assessment Guidance for Superfund, Volume 1 -Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). EPA/540/R-92/003.*

USEPA. October 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. EPA/540/G-90/004.*

USEPA. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002.

USEPA. August 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Interim). EPA/540/R/99/005.

Tables

Table 1-1
History of Environmental Investigations
Site 11, NAB Little Creek
Virginia Beach, Virginia

Date of Report	Author	Report Title	Purpose of Investigation
December 1984	Rogers, Golden and Halpern	Initial Assessment Study	To identify and assess sites posing a potential threat to human health or to the environment due to contamination from past hazardous materials operations.
October 1986	CH2M HILL	Final Progress Report Round 1 Verification Step	To present the results of the Verification Step, Round 1 sampling at Site 11 performed under the NACIP program. 8 soil samples and 3 groundwater samples were collected for pollutant VOCs and acid extractables, Chromium III & VI, and cyanide.
November 1991	Ebasco Environmental	Interim Remedial Investigation	To determine whether or not further characterization activities or remedial action is warranted at Site 11. 3 groundwater samples, 1 tank liquid sample, and 2 tank solid samples were collected and analyzed for VOCs, acid extractables, and total TAL metals.
November 1994	Foster Wheeler Environmental	Final Remedial Investigation/Feasibility Study	To fill information gaps and collect additional site-specific data necessary to fully evaluate site conditions, determine potential risks posed by each site, and develop and evaluate remedial action alternatives to mitigate any risks found. 3 groundwater samples were collected and analyzed for VOCs and total and dissolved metals. 10 surface soil samples were analyzed for VOCs and 5 surface soils were analyzed for metals.
May 1996	IT Corporation	Draft Final Closeout Report for Site 11	Document the soil conditions after the removal of the neutralization tank and piping.18 subsurface soil samples were collected and analyzed for VOCs and 8 metals.
February 1998	CH2M HILL	February 1998. Final Groundwater Monitoring Report, Sites 5 and 11	Monitor and document the groundwater conditions after the removal of the neutralization tank and piping. 3 groundwater samples were collected in March and December for VOCs and
June 2004	CH2M HILL	Supplemental Remedial Investigation for Site 11	DPT and MIP sampling to establish the horizontal and vertical extent of the VOC and PCP plumes, the VOC source area, and aquifer (shallow and deep) characteristics, to conduct a Human Health Risk Assessment, and to evaluate the integrity of the sanitary sewer. Soil, subsurface soil, and groundwater collected and analyzed for VOCs, SVOCs, and/or metals.
June 2000	CH2M HILL	Screening Ecological Risk Assessment, IR Sites 5, 7, 9, 10, 11, 12, 13, & 16, and SWMU 3	To confirm the absence of potential ecological risks.
2002	ESTCP. Boving et al.	Draft Cyclodextrin Enhanced In-situ Removal of Organic Contaminants from Groundwater at Department of Defense Sites	Evaluate the in-situ removal of organic contaminants from groundwater using a cyclodextrin solution.
July 2003	CH2M HILL	Summary of Site 11 Cyclodextrin Pilot Study Post-Treatment Groundwater Sampling.	To assess the impact of the cyclodextrin solution on the groundwater. Groundwater samples were collected and analyzed for VOCs
November 2003	CH2M HILL	NAB Little Creek Sites 11, 11a, and 13 Membrane Interface Probe Investigation and Associated Confirmation Sampling	MIP investigation and groundwater sampling to further assess the impact of the cyclodextrin solution on the groundwater.

Table 1-2 Summary of VOC RME Cancer Risks and Hazard Indices Site 11, NAB Little Creek Virginia Beach, Virginia						
Receptor	Media	Exposure Route	Cancer Risk	COPCs with Cancer Risks >10^{-4}	Hazard Index	COPCs with HI > 1
Future Resident Adult	Groundwater	Ingestion	NA		5.5E+02	1,1,1-Trichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethene (total), Carbon tetrachloride, Trichloroethene, Vinyl chloride,cis-1,2-Dichloroethene
		Inhalation	1.3E-02	Carbon tetrachloride, Trichloroethene, Vinyl chloride, 1,1,2-Trichloroethane, 1,2-Dichloroethane, Chloroform, Methylene chloride	1.1E+02	1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloropropane, Vinyl chloride, trans-1,2-Dichloroethene, Carbon tetrachloride and Methylene chloride
		Dermal Contact	NA		8.3E+01	1,2-Dichloroethene (total), Carbon tetrachloride, Vinyl chloride,cis-1,2-Dichloroethene
		Total	1.3E-02		7.5E+02	
		Receptor Total	1.3E-02		7.5E+02	
Future Resident Child	Groundwater	Ingestion	NA		1.3E+03	1,1,1-Trichloroethane, 1,1-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethene (total), Carbon tetrachloride, Methylene chloride, Trichloroethene, Vinyl chloride,cis-1,2-Dichloroethene, trans-1,2-Dichloroethene
		Inhalation	NA		NA	
		Dermal Contact	NA		1.9E+02	1,2-Dichloroethene (total), Carbon tetrachloride, Trichloroethene, Vinyl chloride,cis-1,2-Dichloroethene
		Total	NA		1.5E+03	
		Receptor Total	NA		1.5E+03	
Future Resident Child/Adult	Groundwater	Ingestion	6.0E-02	Carbon tetrachloride, Methylene chloride, Trichloroethene, Vinyl chloride	NA	
		Inhalation	NA		NA	
		Dermal Contact	3.5E-03	Carbon tetrachloride, Vinyl chloride	NA	
		Total	6.3E-02		NA	
		Receptor Total	6.3E-02		NA	
Future Industrial Worker	Groundwater	Ingestion	6.1E-04	Carbon tetrachloride, Vinyl chloride	2.0E+02	1,2-Dichloroethene (total), Carbon tetrachloride, Trichloroethene, Vinyl chloride,cis-1,2-Dichloroethene
		Inhalation	NA		NA	
		Dermal Contact	NA		NA	
		Total	6.1E-04		2.0E+02	
		Receptor Total	6.1E-04		2.0E+02	
Future Construction Worker	Groundwater	Ingestion	NA		NA	
		Inhalation	3.5E-05		6.9E+00	1,1-Dichloroethane, Vinyl chloride
		Dermal Contact	8.3E-05		5.5E+01	1,2-Dichloroethene (total), Carbon tetrachloride, Vinyl chloride
		Total	1.2E-04		6.2E+01	
		Receptor Total	1.2E-04		5.5E+01	

Note: Pentachlorophenol exceeds acceptable risks associated with residential dermal exposure to groundwater and will be addressed with this FS.

Table 2-1 Summary of Groundwater PRGs Site 11, NAB Little Creek Virginia Beach, Virginia		
COPC	PRG (UG/L)	SOURCE
1,1,1-Trichloroethane	200	MCL
1,1,2-Trichloroethane	5	MCL
1,1-Dichloroethane	2,900	Calculated PRG*
1,1-Dichloroethene	7	MCL
1,2-Dichloroethane	5	MCL
1,2-Dichloropropane	5	MCL
Carbon tetrachloride	5	MCL
Chloroform	80	MCL
Methylene chloride	5	MCL
Trichloroethene	5	MCL
Vinyl chloride	2	MCL
cis-1,2-Dichloroethene	70	MCL
trans-1,2-Dichloroethene	100	MCL

*PRG Calculation is provided in Appendix C and is based on USEPA Guidance Document. USEPA. December 1991. *Risk Assessment Guidance for Superfund, Volume 1 -Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). EPA/540/R-92/003.*

Table 3-1
Alternative 2 - ERD
Proposed Performance Monitoring Schedule
Site 11, NAB Little Creek
Virginia Beach, Virginia

Parameter	First Year	Year 1-14	Year 15+
Microbiological parameters: (*Dehalococcoides, Dehalobacter*, BAV-1*, and phospholipid fatty acids)	Semi-annually	NA	NA
Field parameters: (pH, temperature, dissolved oxygen, oxidation-reduction potential, specific conductance)	Monthly for first 6 months Bimonthly rest of year (9 events)	Quarterly (4 events per year)	Annually
Total organic carbon, methane, ethane, ethene, volatile organic compounds	Monthly for first 6 months Bimonthly rest of year (9 events)	Quarterly (4 events per year)	Annually
Geochemical parameters: (dissolved iron, dissolved manganese, sulfate, sulfide)	Bimonthly	Semi-annually	Annually
Volatile fatty acids	Monthly for first 6 months Bimonthly rest of year (9 events)	Annually	Annually

* Analysis of functional gene for strain BAV-1, which is associated with the reductive dechlorination of vinyl chloride

Table 3-2
Alternative 3 - ERH & ERD
Proposed Performance Monitoring Schedule
Site 11, NAB Little Creek
Virginia Beach, Virginia

Parameter	First Year	Year 1-14	Year 15+
Microbiological parameters: (*Dehalococcoides, Dehalobacter*, BAV-1*, and phospholipid fatty acids)	Semi-annually	NA	NA
Field parameters: (pH, temperature, dissolved oxygen, oxidation-reduction potential, specific conductance)	Monthly for first 6 months, with 2 events in month four. Bimonthly rest of year (10 events)	Quarterly (4 events per year)	Annually
Total organic carbon, methane, ethane, ethene, volatile organic compounds	Monthly for first 6 months, with 2 events in month four. Bimonthly rest of year (10 events)	Quarterly (4 events per year)	Annually
Geochemical parameters: (dissolved iron, dissolved manganese, sulfate, sulfide)	Bimonthly	Semi-annually	Annually
Volatile fatty acids	Monthly for first 6 months, with 2 events in month four. Bimonthly rest of year (10 events)	Annually	Annually

* Analysis of functional gene for strain BAV-1, which is associated with the reductive dechlorination of vinyl chloride

Table 4-1
Detailed Evaluation of Remedial Alternatives
Site 11 FS, NAB Little Creek
Virginia Beach, Virginia

Evaluation Criteria	Alternative 1 No Action	Alternative 2 ERD	Alternative 3 ERH & ERD
Overall Protection of Human Health and the Environment	Not protective of human health and the environment.	Adequate protection of human health and the environment through groundwater treatment. LUCs and a groundwater monitoring will enusre protection is maintained.	Adequate protection of human health and the environment through groundwater treatment. LUCs and a groundwater monitoring will enusre protection is maintained.
Compliance with ARARs	Does not achieve ARARs.	Alternative 2 will comply with chemical-, location-, and action-specific ARARs.	Alternative 3 will comply with chemical-, location-, and action-specific ARARs.
Long-Term Effectiveness and Permanence	Does not provide long-term effectiveness and permanance.	This alternative would provide long-term effectiveness and permanance.	This alternative would provide long-term effectiveness and permanance.
Reduction of Toxicity, Mobility, and Volume Through Treatment	Does no provides reduction of toxicity, mobility, and volume through treatment.	Alternative 2 is expected to reduce toxicity, mobility, and volume through treatment via substrate injection to enhance biological degradation of VOCs in the source area, the area proximal to LS11-MW10D, and as a biobarrier in the downgradient plume.	Alternative 3 is expected to reduce toxicity, mobility, and volume through treatment via ERH in the source zone and ERD in the source area, the area proximal to LS11-MW10D, and as a biobarrier in the downgradient plume.
Short Term Effectiveness	No concerns for short term effectiveness.	Alternative 2 requires the installation of monitoring and injection wells and regularly scheduled injections and monitoring events throughout the life of the project. Potential exposures associated with Alternative 2 would be minimized with appropriate protective equipment.	Alternative 3 requires well abandonment, well installation, construction and operation of the ERH system, and regularly scheduled injections and monitoring events throughout the life of the project. Potential exposures associated with Alternative 3 would be minimized with appropriate protective equipment. Since ERH includes an ex situ component, engineering controls will be required.
Implementability	No action is easily implemented.	ERD is a proven technology. Wells can be installed by an experienced environmental drilling company. Disruption to current land use will occur during well installation, injection, and groundwater monitoring events. This alternative is administratively feasible.	ERH and ERD are proven technologies. Well abandonment and installation can be completed by an experienced environmental drilling company. Disruption to current land use will occur during well installation, injection, and groundwater monitoring events. Additionally, since the ERH system has an *ex situ* component daily use of the site will be impeded during operation and construction and engineering controls will be required. This alternative is administratively feasible.
Present Value Cost	$0	$2,399,000	$2,841,000

Table 4-2
Comparative Analysis of Remedial Alternatives
Site 11 FS, NAB Little Creek
Virginia Beach, Virginia

Evaluation Criteria	Alternative 1 No Action	Alternative 2 ERD	Alternative 3 ERH & ERD
Overall Protection of Human Health and the Environment	1	5	3
Compliance with ARARs	1	5	5
Long-Term Effectiveness and Permanence	1	5	5
Reduction of Toxicity, Mobility, and Volume Through Treatment	1	3	5
Short Term Effectiveness	5	3	1
Implementability	5	3	1
Cost	5	3	1
Total	19	27	21

Qualitative comparative analysis of alternatives using a rating scale of 1, 3, and 5 (1 = lowest score, 5 = highest score)
Shading designates the preferred alternative.

Figures

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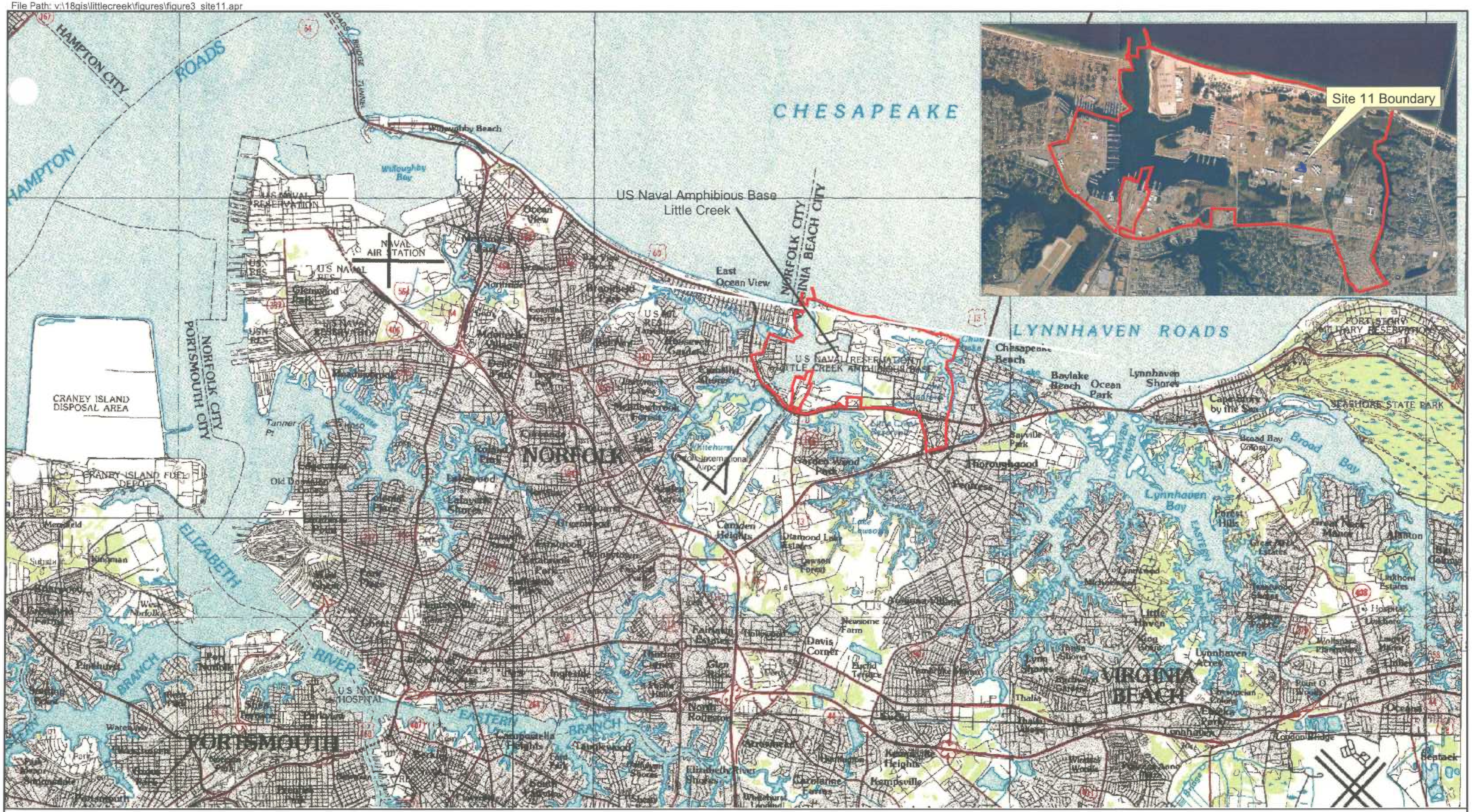

LEGEND

Base Boundary

Site 11 Boundary

N

0 6000 12000 18000 Feet

Figure 1-1
NAB Little Creek & Site 11 Location Map
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

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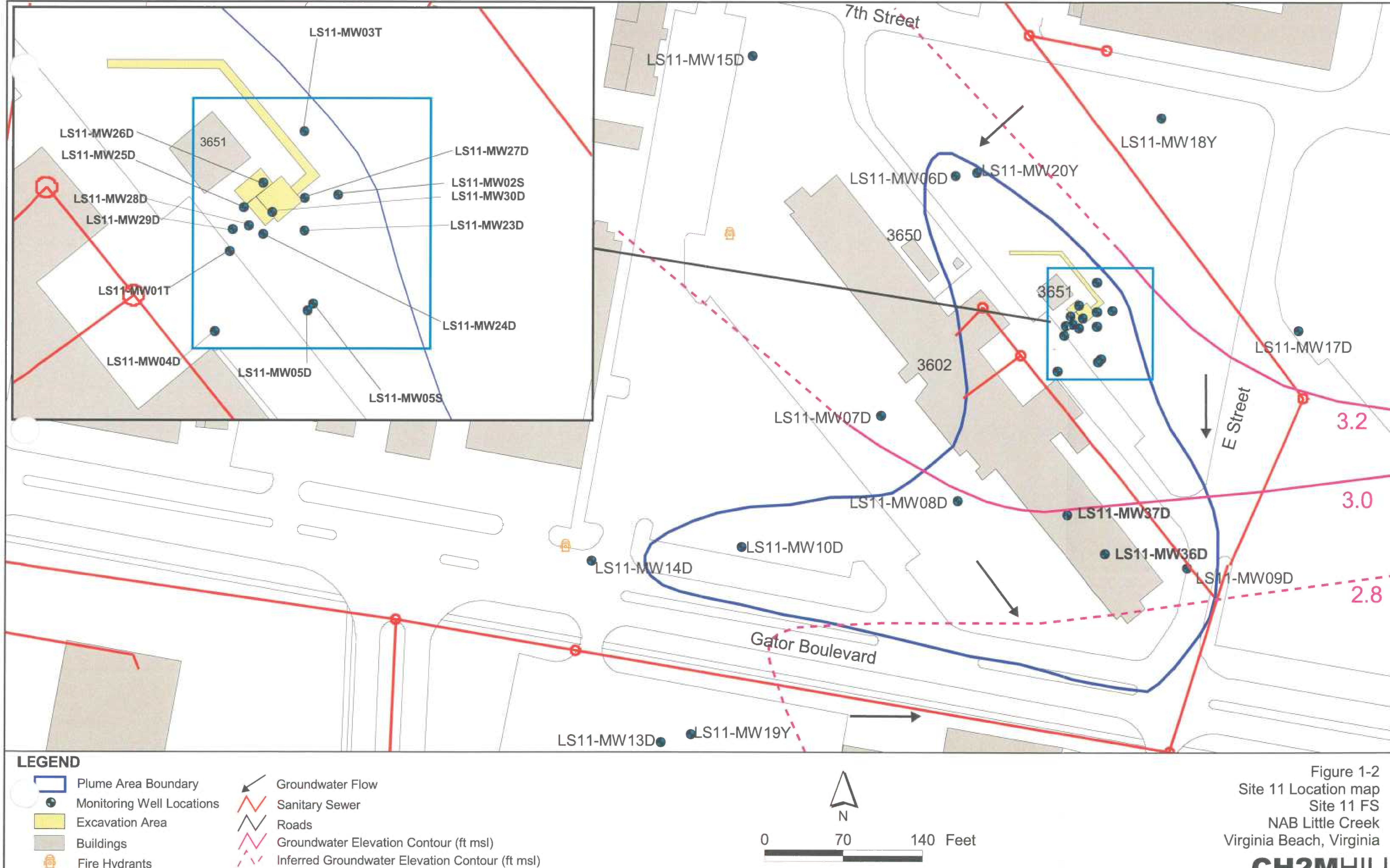

Figure 1-2
Site 11 Location map
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

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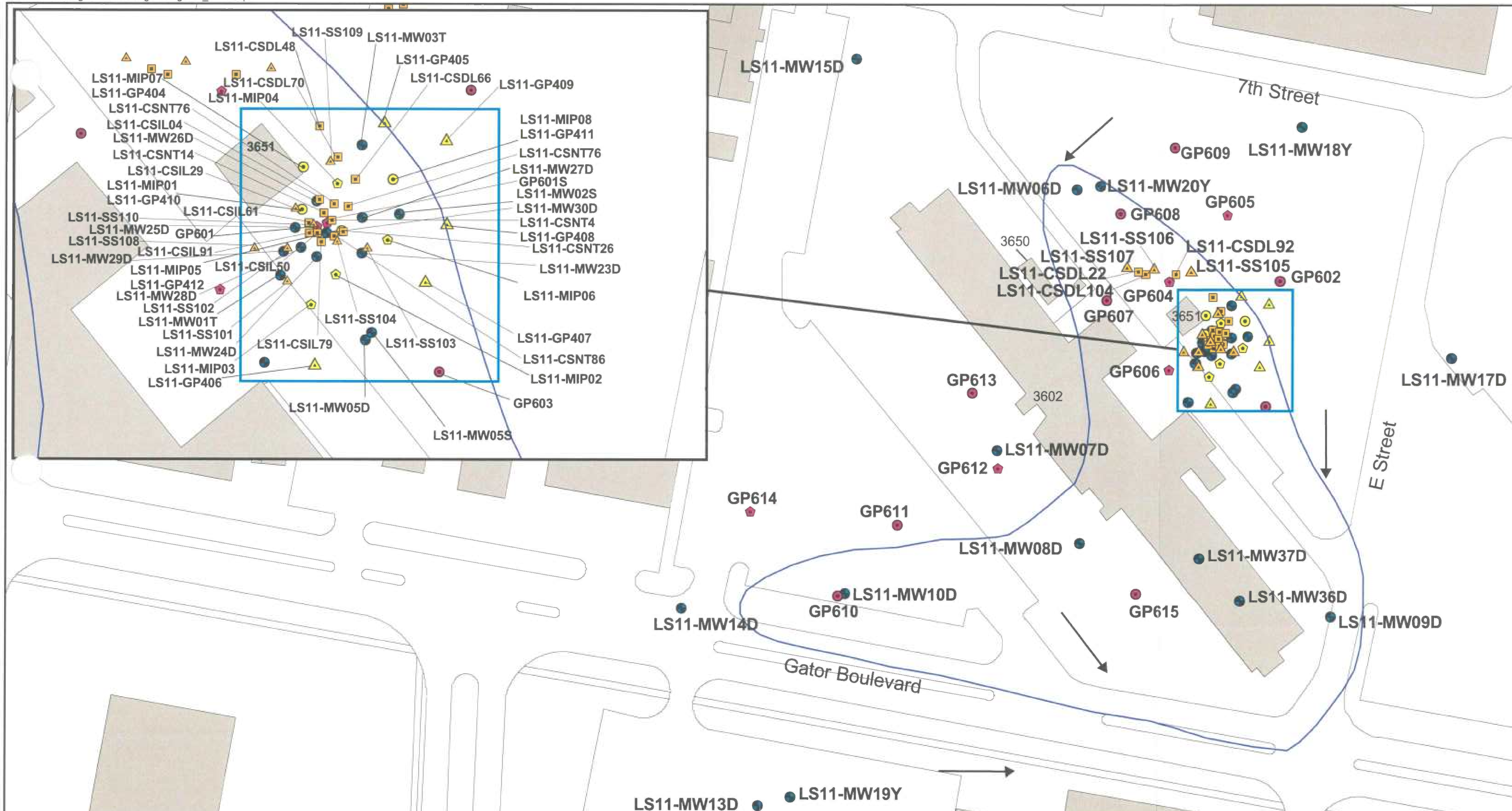

LEGEND

- Plume Area Boundary
- Monitoring Well Locations
- Geoprobe and MIP Sample Locations (2001)
- Geoprobe Sample Locations (2001)
- MIP Sample Locations (2001)
- MIP and Geoprobe Sample Locations (2003)
- MIP Sample Locations (2003)
- Surface Sample Locations (1993)
- Subsurface Sample Locations (1995)
- Groundwater Flow
- Buildings
- Roads

N

0 70 140 Feet

Figure 1-3
Site 11 Sample Locations
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

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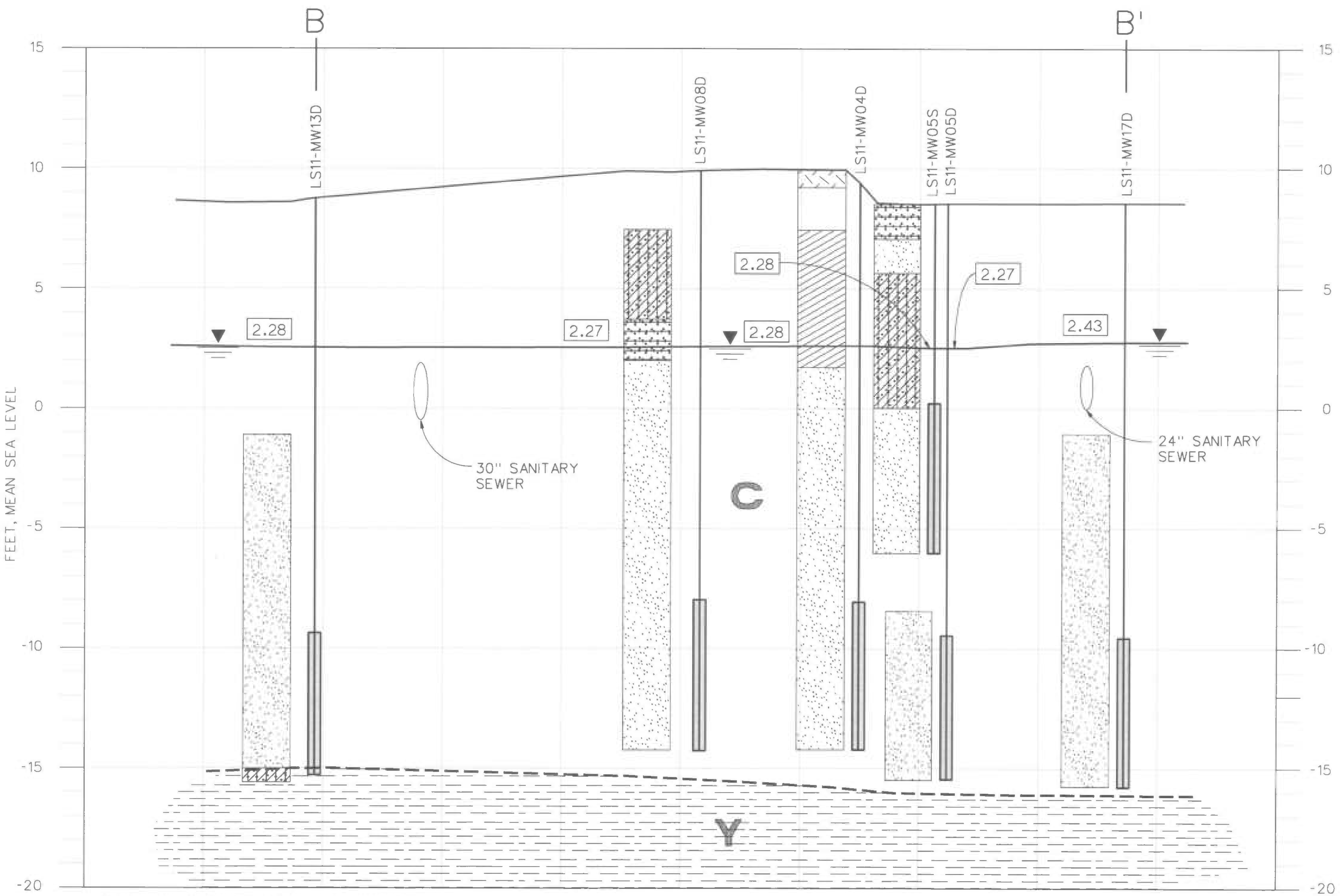

* GROUND ELEVATIONS ARE APPROXIMATE

NOTE:
THIS CROSS SECTION IS INTERPRETIVE AND WAS PREPARED BY INTERPOLATION BETWEEN BORING LOCATIONS. ACTUAL CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THOSE SHOWN HERE.

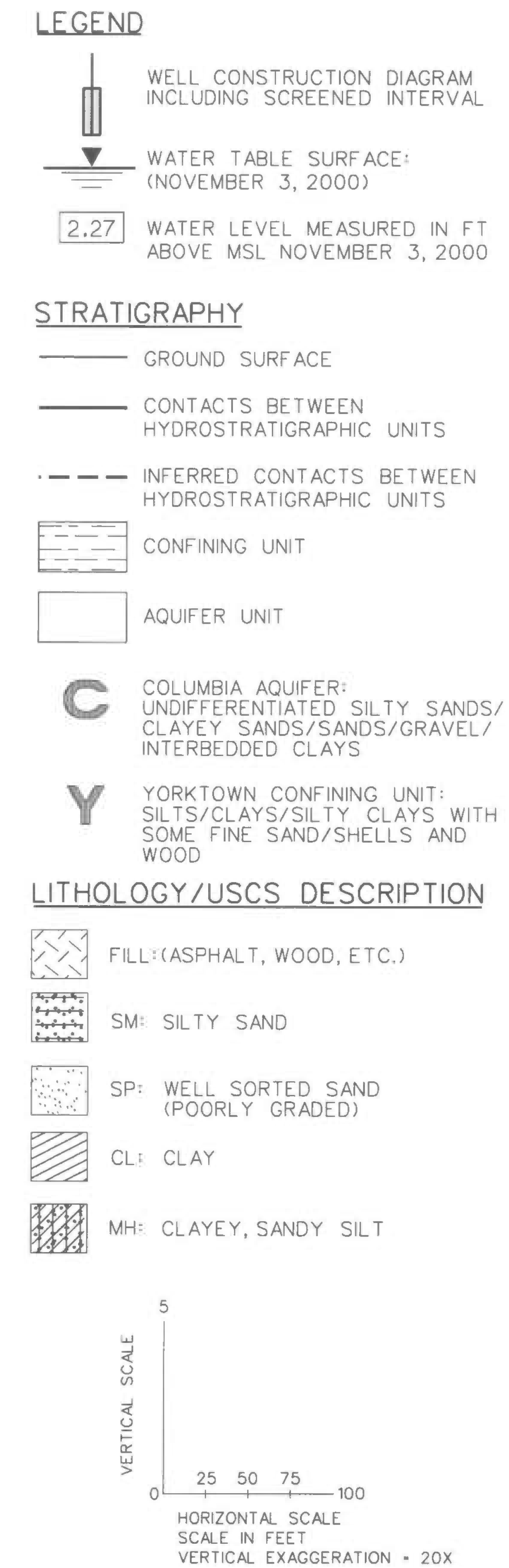

FIGURE 1-4
HYDROSTRATIGRAPHIC CROSS-SECTION B-B'
WATER TABLE SURFACE (NOVEMBER 3, 2000)
SITE 11 FS
NAB LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

15-FEB-2006 7234f100.dgn

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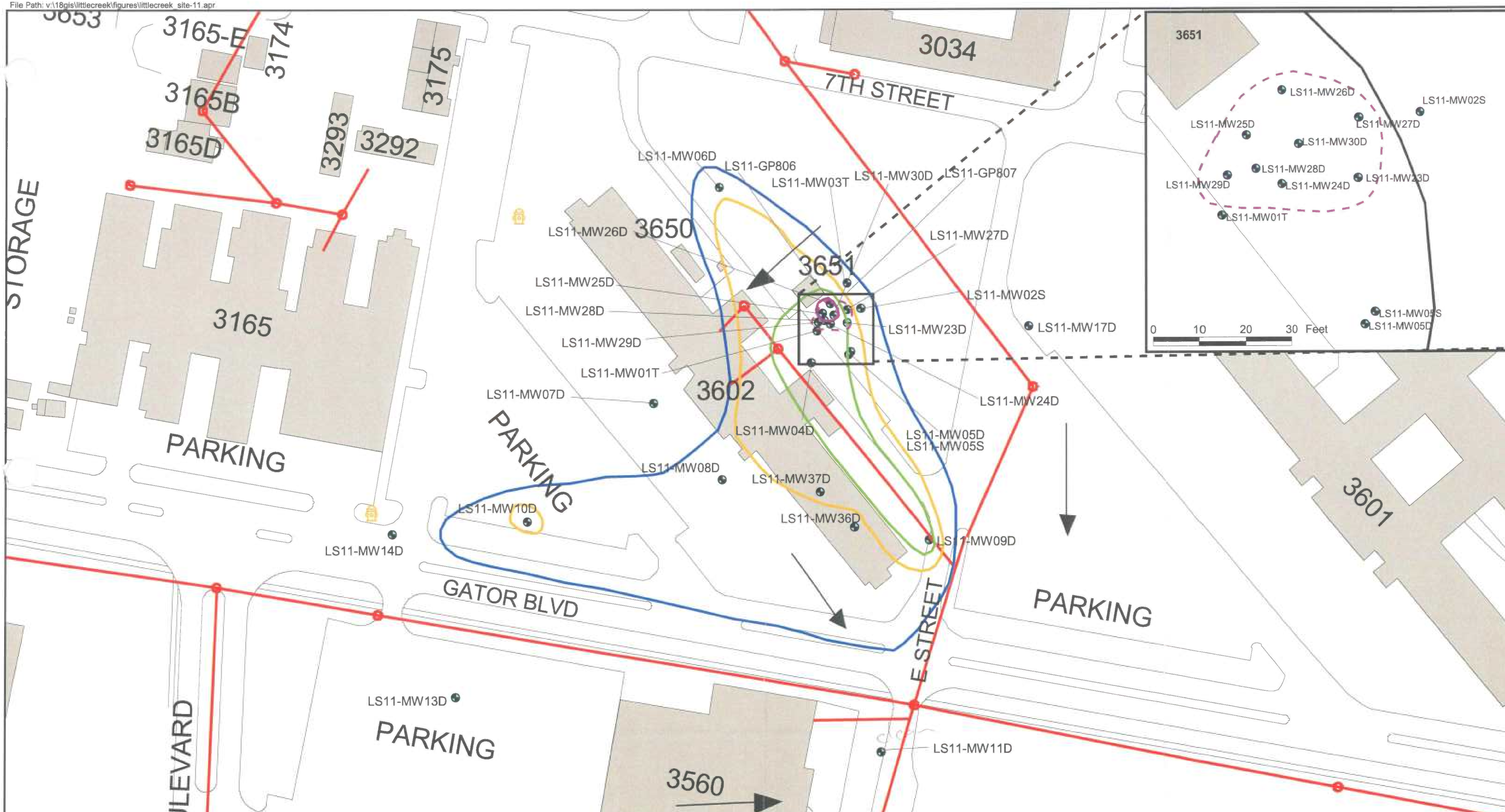

LEGEND

- Existing Monitoring Well
- Source Area
- Sanitary Sewer
- Groundwater Flow Direction
- Fire Hydrants

Total VOC Concentration (ug/L)

- 1 - 100 (Plume Area Boundary)
- 100 - 1,000
- 1,000 - 100,000
- 100,000 +

Note: The groundwater isoconcentration map depicts deep Columbia aquifer concentrations at Site 11.

Isoconcentrations are based on 2005 Analytical Results.

N

0 50 100 150 200 Feet

Figure 1-5
Total VOC Groundwater Plume
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

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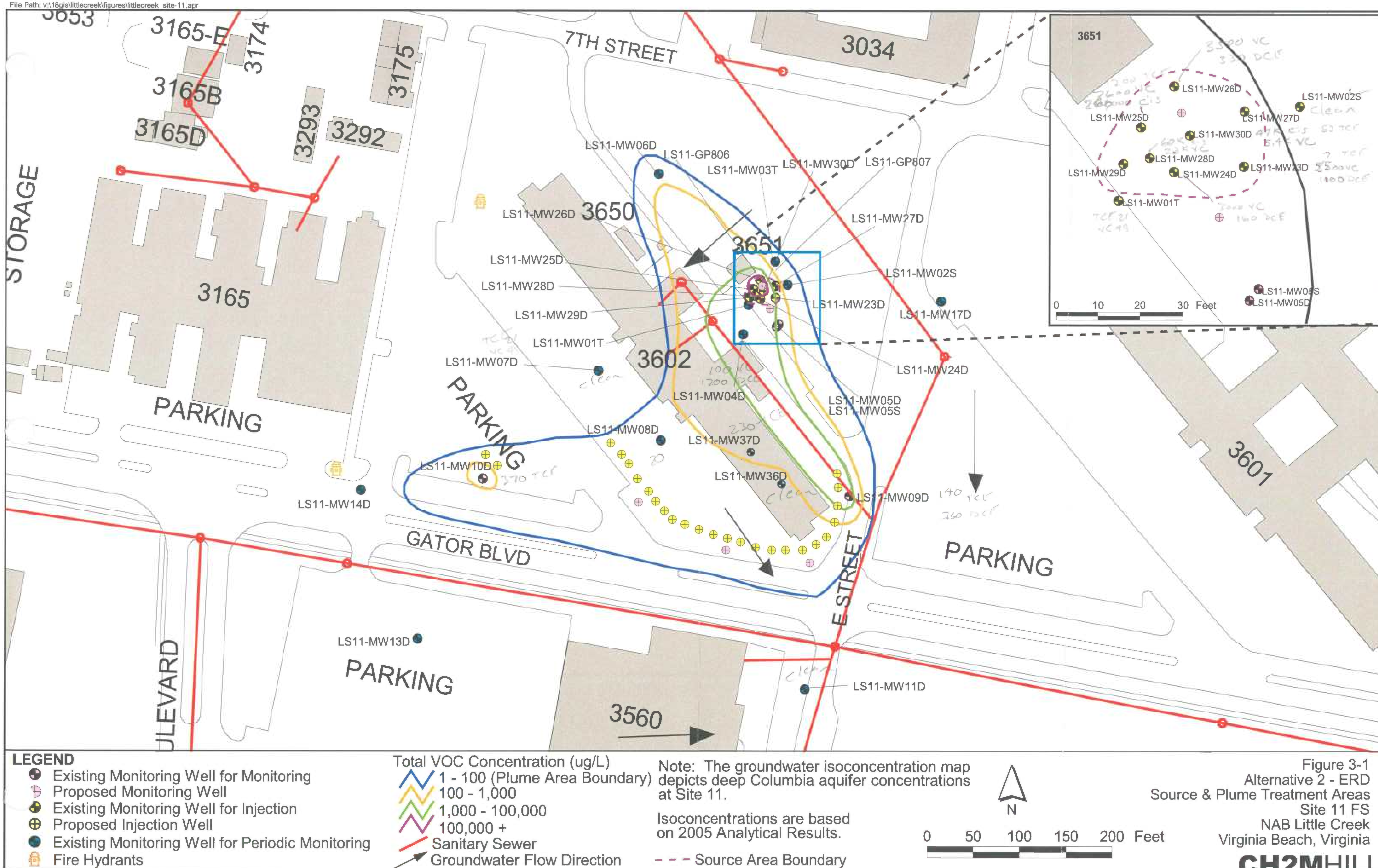
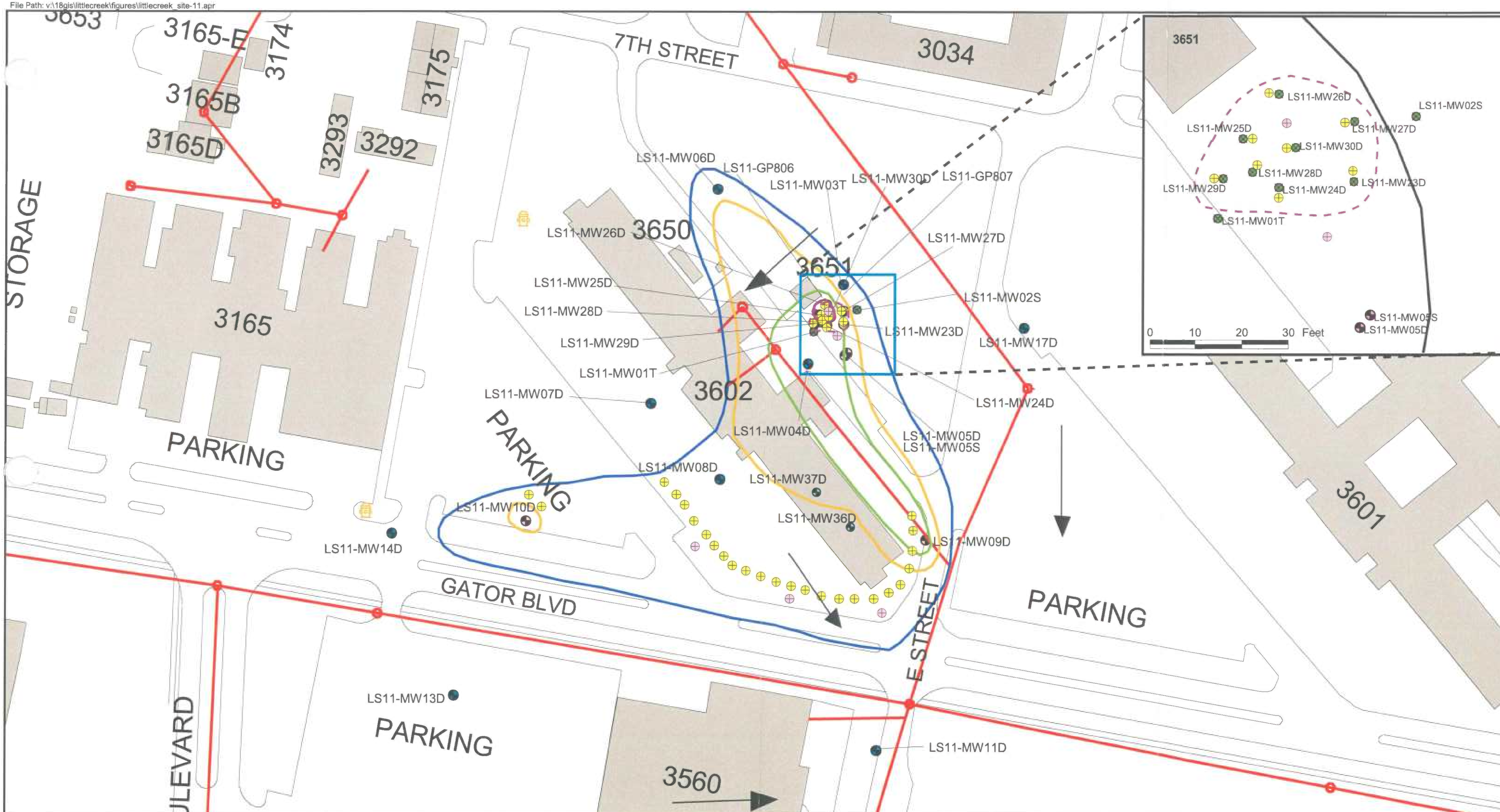


Figure 3-1
Alternative 2 - ERD
Source & Plume Treatment Areas
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL



LEGEND

- Existing Monitoring Well for Monitoring
- Proposed Monitoring Well
- Proposed Injection Well
- Proposed Abandoned Monitoring Well
- Existing Monitoring Well for Periodic Monitoring
- Fire Hydrants

Total VOC Concentration (ug/L)

- 1 - 100 (Plume Area Boundary)
- 100 - 1,000
- 1,000 - 100,000
- 100,000 +
- Sanitary Sewer
- Groundwater Flow Direction

Note: The groundwater isoconcentration map depicts deep Columbia aquifer concentrations at Site 11.

Isoconcentrations are based on 2005 Analytical Results.

- - - Source Area Boundary

N

0 50 100 150 200 Feet

Figure 3-2
Alternative 3 - ERH & ERD
Source & Plume Treatment Areas
Site 11 FS
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

Appendix A
Vapor Intrusion Assessment, Site 11

Vapor Intrusion Assessment, Site 11, Naval Amphibious Base Little Creek

PREPARED FOR: NAB Little Creek Partnering Team

PREPARED BY: CH2M HILL

COPIES:

DATE: September 8, 2005

Introduction

This technical memorandum summarizes the results of the vapor intrusion assessment of Building 3602, overlying Installation Restoration Site 11 at Naval Amphibious Base (NAB) Little Creek, Virginia Beach, Virginia. Site 11 is a chlorinated volatile organic compound (VOC) plume in groundwater underlying the School of Music Building 3602. To identify potential vapor intrusion pathways, a site visit was conducted in May 2005 to assist the Navy with evaluating whether the groundwater contamination poses a risk to building occupants. Based on the conclusions of the site visit, a sampling plan to further evaluate the indoor vapor intrusion pathway and potential human health risk was developed and agreed upon by the NAB Little Creek Tier I Partnering Team. The objectives for the field effort were to:

- Determine chlorinated VOC concentrations in groundwater in the upper portion of the shallow aquifer around the building through the collection of eight grab groundwater samples.
- Collect a grab sample of water from a sump in the basement of Building 3602 for VOC analysis to evaluate if a potential vapor intrusion pathway is present in the basement mechanical room.

Results from the shallow groundwater sampling, completed on June 27 and 28, 2005, were used to identify and assess human health risk due to potential vapor intrusion pathways. Site background, sampling methods, analytical results, risk assessment and the conclusions from the vapor intrusion risk assessment are summarized below.

Site Background

Site 11 is located in the eastern portion of NAB Little Creek, near the intersection of 7th and E Streets (**Figure 1**). Site 11 consists of a VOC groundwater plume from a former in-ground concrete tank and associated piping used to neutralize plating solutions. The approximate extent of groundwater contamination is shown on **Figure 1**. The groundwater plume underlies Building 3602 (the School of Music) and Building 3651 (the former School of Music Plating Shop). Building 3602 is a rectangular 24,000 square foot building (approximately

The site visit to Building 3602 was conducted during normal business hours under sunny skies and with temperatures in the mid- to high-60 degree F range[2]. The survey included an inspection of the heating, ventilating and air conditioning (HVAC) system to identify the potential for depressurization relative to ambient conditions. Depressurization can potentially create advective flow of soil gas (and volatile contaminants in soil gas) into indoor air. The basement and first floor were inspected for potential vapor intrusion entry points and to evaluate ventilation characteristics in the inhabited areas. Additionally, a limited review of the building plans and chemical inventory for the building was completed to identify potential indoor sources for the constituents of interest in the subsurface (TCE) was also complete. Photographs taken during the site visit are presented in **Attachment A.**

Building Envelope

Observations made during the site visit indicate that there are limited pathways for soil gas to intrude into the building. According to 1954 structural as-built construction drawings, the building was constructed on fill, approximately 2.5' to 3' above grade. The slab is approximately 6" thick concrete overlain with 2 layers of vinyl floor tile. There were few penetrations through the first floor slab indicated on the drawings. The building was originally constructed with large open areas for crew quarters and bunks; the first floor had been renovated to create several small music practice rooms. Rain leaders from the roof do penetrate the slab at approximately 12 locations; however, in the subsequent renovations, the leaders appear to have been encased inside wall cavities. It was noted that exterior wall penetrations for steam piping for corridor radiators occurred at first floor level, which is approximately 3 feet above grade.

The below-grade mechanical room originally housed a water cooled chiller. In the 1988 renovation, the chiller was moved to an outdoor location. Currently, the room is used for storage. Based on the 1954 drawings and site observations, the mechanical room slab appears to be approximately 8 to 10 inches thick. Cracks in the slab were not observed; one penetration in the floor of the mechanical room, approximately 4" in diameter, was noted. There were small areas of dampness in the room and staining on the walls. Personnel have reported that the mechanical room had been flooded during a recent rainfall event.

A floor sump for the collection of steam condensate is located in the northeast corner of the below-grade mechanical room. The drawings indicate that the sump is fully lined with concrete. Based on a review of the drawings and water levels for the nearby monitoring wells, the sump and a portion of the mechanical room are below the water table.

Water seeps into the below-grade mechanical room during rain events at several openings around steam conduit pipes that enter the room at ground surface. Smoke testing indicated that the first floor was under a positive pressure relative to the mechanical room (smoke moved from the first floor to the mechanical room). Smoke moved upwards through one pipe penetration between the mechanical room and the first floor room containing air handling unit labeled AHU-3, indicating air from the basement does move into that air handling unit room.

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[2] http://www.wunderground.com/history/airport/KORF/2005/5/23/MonthlyHistory.html#calendar

In addition to the eight DPT samples collected from the top of the aquifer adjacent to Building 3602, a grab sample was collected from the floor steam condensate sump in the mechanical room (basement) of Building 3602. This sample was collected using a peristaltic pump with low-flow sampling protocol. Samples were sent to an off-site laboratory (Mitkem Corporation, Warwick, RI) for analysis of Target Compound List (TCL) Low Concentration (LC) VOCs by Contract Laboratory Program (CLP) method OLC03.

Quality Control

Quality assurance (QA)/QC samples were collected during the field activities in order to evaluate field methodologies (duplicates), evaluate whether cross contamination had occurred during sampling or shipping (equipment and trip blanks), establish field ambient conditions (field blanks), and measure sample-specific interference due to sample matrix (matrix spike (MS)/matrix spike duplicates (MSD). Two laboratory trip blanks and two equipment blanks were collected (one per day). One duplicate, one field blank, and one MS/MSD were collected during the sampling event.

For all samples, laboratory prepared, pre-preserved bottles for VOC analysis were filled completely with the aqueous sample to minimize aeration, and capped to prevent the entrapment of any air bubbles in the vial. All samples were labeled with the predetermined identification number. Samples were packed on ice for overnight shipment to an off-site laboratory. Temperature blanks were included in each cooler to confirm sample temperatures were less than 4 degrees Celsius when received by the laboratory.

Field samples and their corresponding analytical tests were recorded on chains-of custody (COC). Upon receipt of the samples by the laboratory, a comparison to the field information was made to determine if the samples, including the QA/AC samples, were documented correctly.

Decontamination and Investigation Derived Waste Procedures

All non-disposable sampling equipment, such as the direct push stainless steel rods and well screen, were decontaminated immediately after each use in accordance with applicable SOPs included with the Master Project Plans (MPP) Field Sampling Plan (FSP) checklist (CH2M HILL, August 2000). Investigation derived waste (IDW) generated during field activities, including purge water and decontamination fluids, were containerized in 55-gallon drums. The 55-gallon drums were properly labeled and are stored at a location designated by NAVFAC and NAB Little Creek pending disposal.

Analytical Results

The location of the DPT groundwater samples and the basement sump sample is illustrated on **Figure 3**. A complete summary of the analytical results are provided in **Table 1**. There were no VOC detections in six of the eight DPT shallow groundwater samples. Only two VOCs were detected: chloromethane (1.7 micrograms per liter [μg/l] at GP704) and TCE (6.3 μg/l at GP705). There were no VOCs detected in the grab sample collected from the basement sump.

required before the contaminant becomes available for volatilization into the overlying vadose zone. Once the volatilized contaminant reaches the building's zone of influence, convective air movement within the soil column transports the vapors through cracks between the foundation and the basement slab floor. This convective sweep effect is induced by a negative pressure within the structure caused by a combination of wind effects and stack effects due to building heating and mechanical ventilation.

The Johnson and Ettinger (1991) model was used to calculate risk-based screening levels in groundwater. These screening levels were based on standard default worker exposure assumptions (250 days/year exposure frequency, 25 years exposure duration). Use of these worker exposure assumptions probably overstates potential exposures and risks actually associated with activities in Building 3602, since most of the individuals in Building 3602 are active-duty personnel. The groundwater, building, and intake parameters used in the Johnson and Ettinger (1991) model are presented in **Table 2**.

Building parameters were obtained from the site visit and construction plans, while the soil and groundwater values were taken from boring logs collected during the current and previous site investigations. Some inputs are default values specified in the User's Guide for the Johnson and Ettinger model (USEPA 2004).

Key Assumptions

Key assumptions that were to develop conservative screening levels include the following:

- The model assumes a potential pathway could be present via intrusion through foundation cracks, which may not be consistent with conditions at Building 3602.
- The model assumes that indoor air mixing is restricted to the first floor only. However, the air most likely mixes between floors, which would result in lower indoor air concentrations resulting from vapor intrusion.
- The VOC concentration in groundwater is assumed to be uniform under the building footprint. Most of the samples collected around the building did not detect VOCs in shallow groundwater.
- The model assumes the building is uniformly negatively pressurized relative to underlying soil gas. Actual building conditions observed during the site visit suggest that much of the building may be positively pressurized relative to outdoors.
- The worker receptor chosen in the model is assumed to spend 25 years in the building for 250 days per year--a conservative representation of the population in the building considering the normally short tour length of active duty military personnel (typically not more than five years).

The screening level for TCE was calculated using the cancer slope factor developed by the California Environmental Protection Agency (Cal-EPA, 2005). Updated cancer slope factors for TCE developed by USEPA currently are under review by the National Academy of Sciences (NAS, 2005). NAS is expected to issue a report on USEPA's risk assessment of TCE in June 2006. Pending the outcome of the NAS review, potential risks associated with TCE are being evaluated using toxicity values developed by Cal-EPA.

References

California Environmental Protection Agency. 2005. Toxic Criteria Data Base. http://www.oehha.ca.gov/risk/ChemicalDB/index.asp. Accessed July 2005.

National Academy of Sciences. 2005. Assessing the Human Health Risks of Trichloroethylene: Key Scientific Issues. http://www4.nas.edu/webcr.nsf/0/1dc1b9eb32716bf685256f7f00622ec2?OpenDocument&Highlight=0,Trichloroethylene. Accessed August 2005.

Rivett, M.O. 1995. Soil gas signatures from volatile chlorinated solvents: Borden field experiments. *Ground Water.* 33(1):84-98.

U.S. Environmental Protection Agency. 2004. *User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings.*

U.S. Environmental Protection Agency. 2002. *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance).* November 29, 2002. Federal Register, Vol. 67, No. 230, pages. 71169 - 71172. http://www.epa.gov/epaoswer/hazwaste/ca/eis/vapor.htm

Tables

Table 1
Shallow Groundwater and Basement Sump Analytical Results
Site 11 Vapor Intrusion Assessment
NAB Little Creek
Virginia Beach, Virginia

Sample ID	LS11-BSW1-05C	LS11-GP701-05C	LS11-GP702-05C	LS11-GP703-05C	LS11-GP704-05C	LS11-GP704P-05C	LS11-GP705-05C	LS11-GP706-05C	LS11-GP707-05C	LS11-GP708-05C
Sample Date	7/7/05	7/7/05	7/7/05	7/7/05	7/7/05	7/7/05	7/7/05	7/8/05	7/7/05	7/8/05
Chemical Name										
VOCs (UG/L)										
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Hexanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	0.5 U	0.5 U	0.5 U	0.5 U	1.7	0.5 U	1.7	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methyl acetate	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methyl tert-butyl ether	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylcyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene chloride	0.81 B	0.79 B	0.53 B	0.5 U	0.99 B	1.6 B	0.5 U	0.45 BJ	0.5 U	0.5 U
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	6.3	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Xylenes (Total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Notes:
VOCs- Volatile Organic Compounds
U- Analyte not detected
B- Blank Contamination

TABLE 2
Groundwater to Indoor Air Parameters Used to Calculate Preliminary Cleanup Goals for Indoor Air Scenario Using the Johnson and Ettinger (1991) Model -
Site 11, Naval Amphibious Base, Little Creek

Symbol	Parameter	Description	Selected Value	Units	Sources
T_S	Average Soil/ Groundwater Temperature		14	°C	USEPA, 2004
L_F	Depth Below Grade to Bottom of Enclosed Space Floor	This is the depth from soil surface to the bottom of the floor in contact with soil	15	cm	Based on observations during the Site Visit
L_{WT}	Depth Below Grade to Water Table		152.4	cm	Based on boring log information.
h_A	Thickness of Soil Stratum A		152.4	cm	Thickness of soil stratum A is assumed to be consistent with average depth to groundwater at combined on- and offsite locations.
h_B	Thickness of Soil Stratum B		NA	cm	Not Used
h_C	Thickness of Soil Stratum C		NA	cm	Not Used
	Soil Stratum Directly Above Water Table		A	unitless	Consistent with the deepest stratum with a specified thickness (h_A).
	SCS Soil Type Above Water Table		S	unitless	Soils are assumed to be sand based on grain size data from borings around the building.
	Soil Stratum A SCS Soil Type	Used to estimate soil vapor permeability	S	unitless	
k_v	User-defined Soil Vapor Permeability	A parameter associated with convective transport of vapors within the zone of influence of a building. It is related to the size and shape of connected soil pores	1×01^{-7}	cm^2	Value calculated within the model and is consistent with sand.
ρ_b^A	Stratum A Soil Dry Bulk Density		1.66	g/cm^3	Default value for sand calculated in the model
n^A	Stratum A Total Soil Porosity	Used with water-filled porosity to calculate air-filled porosity (see below)	0.375	unitless	Default value for sand calculated in the model
θ_w^A	Stratum A Soil Water-filled porosity	Used with total porosity to calculate air-filled porosity (see below)	0.054	cm^3/cm^3	Default value for sand calculated in the model
ρ_b^B	Stratum B Soil Dry Bulk Density		NA	g/cm^3	Not Used
n^B	Stratum B Total Soil Porosity	Used with water-filled porosity to calculate air-filled porosity (see below)	NA	unitless	Not Used
θ_w^B	Stratum B Soil Water-filled porosity	Used with total porosity to calculate air-filled porosity (see below)	NA	cm^3/cm^3	Not Used
ρ_b^C	Stratum C Soil Dry Bulk Density		NA	g/cm^3	Not Used

TABLE 3
Preliminary Cleanup Goals for Indoor Air Exposure Scenarios Calculated Using the Johnson and Ettinger (1991) Model
Site 11, Naval Amphibious Base, Little Creek

Compound	Worker, Indoor Air	
	Screening Value (µg/L)	**Concentration in Groundwater (µg/L)**
TCE	29	6.3
Chloromethane	41	1.7

Notes:

Screening values in groundwater are based on 1 x 10^{-6} excess lifetime cancer risk level.

TCE screening value calculated using Cal-EPA cancer slope factor.

Figures

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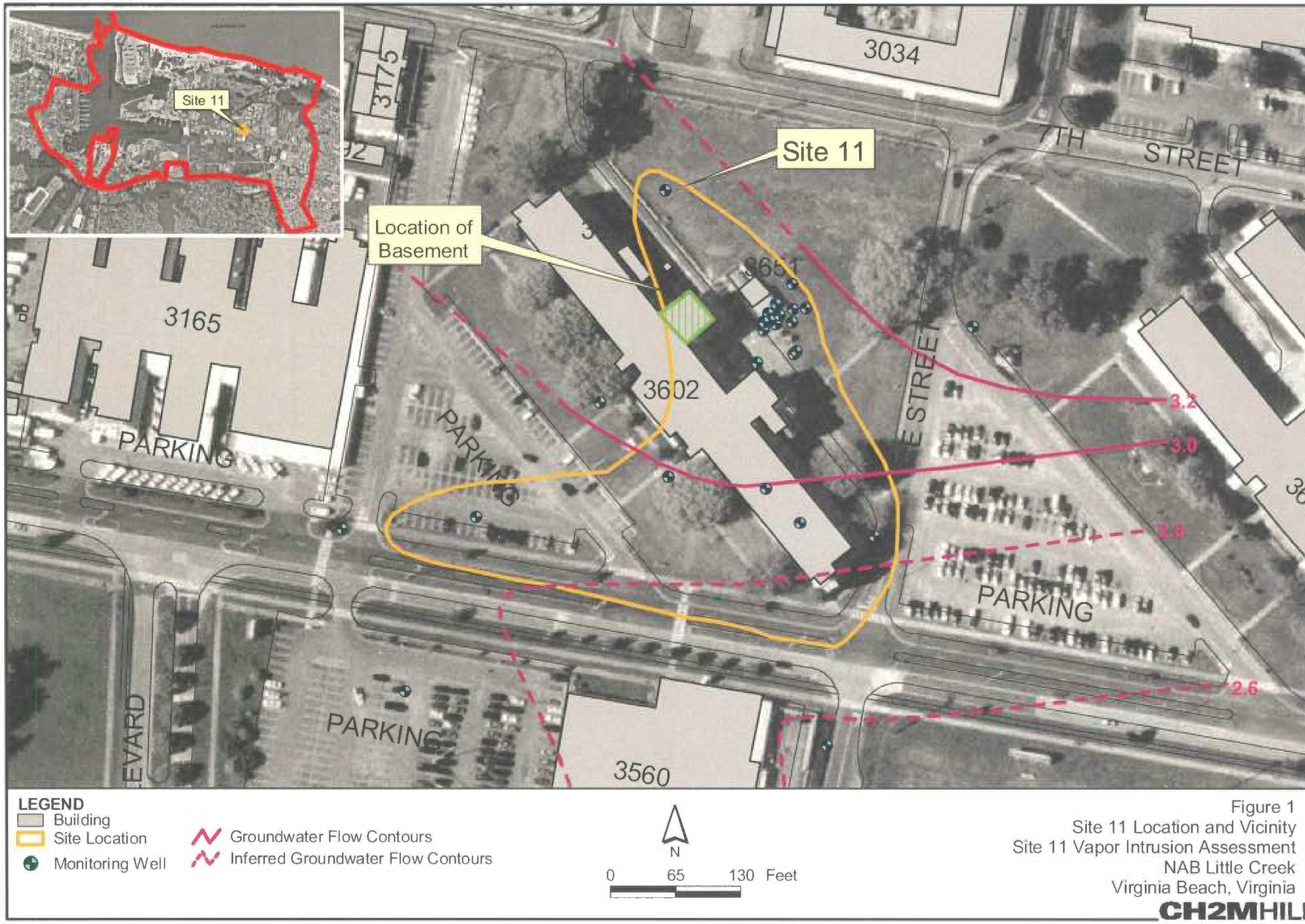

Figure 1
Site 11 Location and Vicinity
Site 11 Vapor Intrusion Assessment
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

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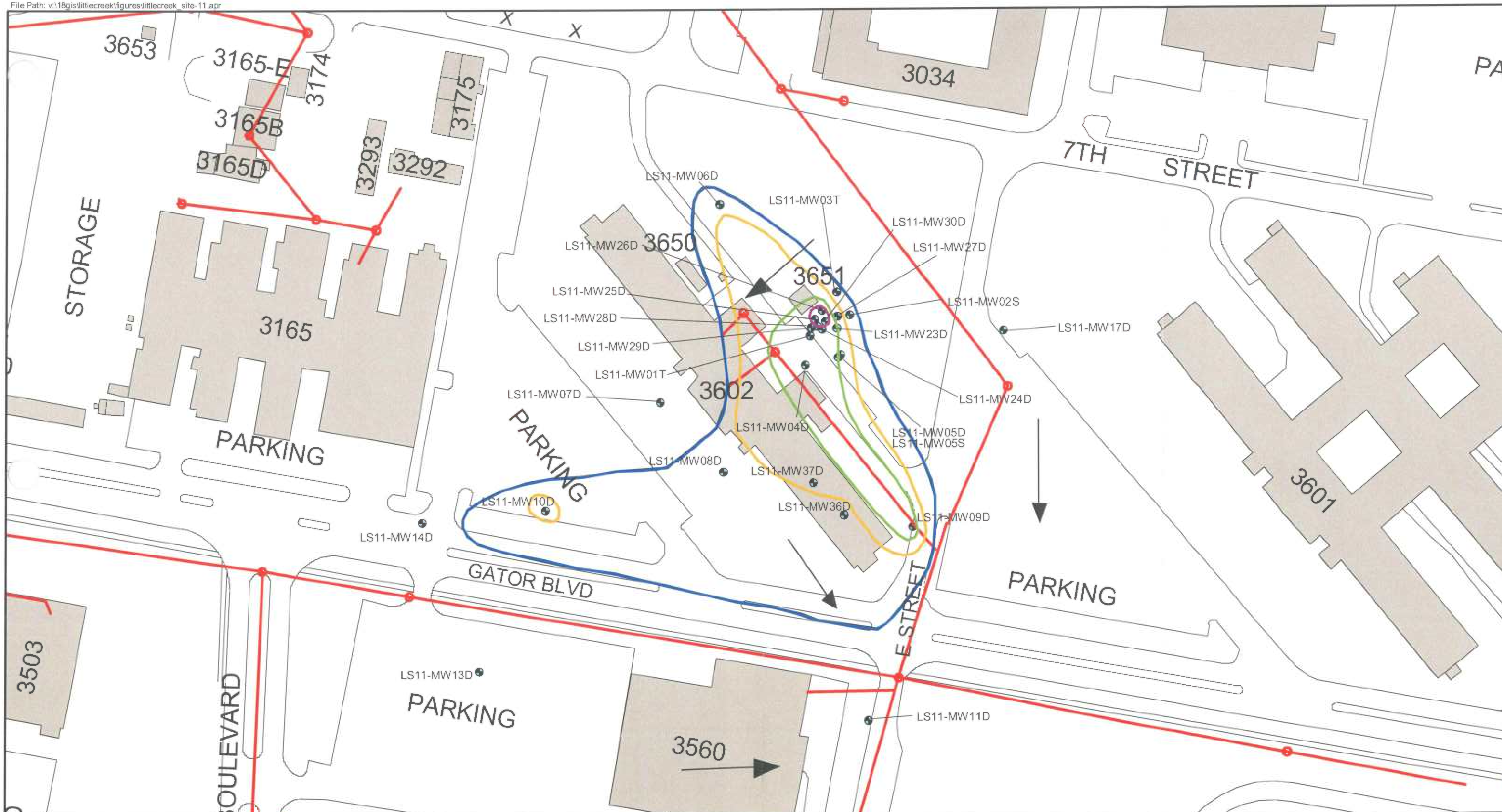

LEGEND

Monitoring Well

Sanitary Sewer

Groundwater Flow Direction

Total VOC Concentration (ug/L)

1 - 100

100 - 1,000

1,000 - 100,000

100,000 +

Note: The groundwater isoconcentration map depicts deep Columbia aquifer concentrations at Site 11.

Isoconcentrations are based on 2005 Analytical Results.

N

0 50 100 150 200 Feet

Figure 2
Total VOC Isoconcentration
Site 11 Indoor Air Assessment
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

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LEGEND

- Building
- Site Location
- Shallow Groundwater Sampling Location
- Basement Sump Sample
- Groundwater Flow Direction

VOC - Volatile Organic Compounds
Conc. - Concentration
BSW - Basement Sump Water
GP - Geoprobe Groundwater

N

0 65 130 Feet

Figure 3
Shallow Groundwater and Basement Floor Sump Sampling Results
Site 11 Vapor Intrusion Assessment
NAB Little Creek
Virginia Beach, Virginia

CH2MHILL

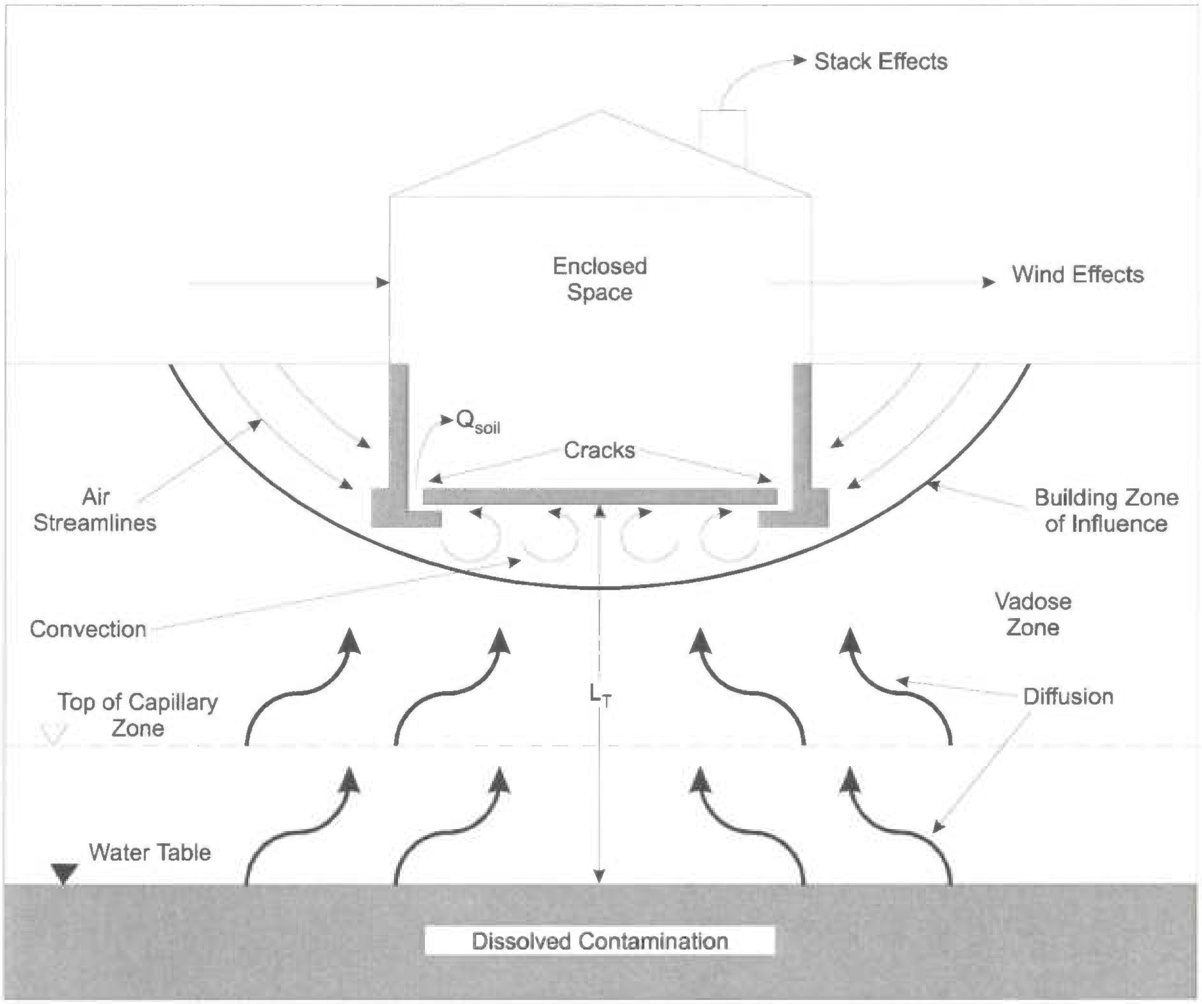

Figure 4
Conceptual Model of VOC Intrusion from Groundwater to Indoor Air
Vapor Intrusion Assessment
Site 11, NAB Little Creek
Virginia Beach, Virginia
CH2M HILL

Attachment A

Southern side of Building 3602 exterior. Building 3651 is in the foreground.

Entrance to the sub-grade mechanical room

Sump for condensate from steam pipe, which has an open drain leading into the sub-grade mechanical room. Mechanical room was flooded from rainfall collecting in this sump.

Sub-grade mechanical room, facing northeast. Sump is in the background.

Close up of sump.

Intrusion from mechanical room ceiling to first floor hallway. Smoke testing indicated that hallway is positively pressured relative to the mechanical room (smoke flowed from hallway to mechanical room).

Intrusion from mechanical room to first floor AHU-3. Smoke testing indicated that AHU-3 was negatively pressured relative to the mechanical room.

Intrusion from mechanical room to first floor hallway. Hallway is pressurized relative to mechanical room.

View from the roof, looking down on an air handling unit room (AHU-3) and outside air intake.

View of Building 3651 from roof of Building 3602.

Supply vent into first floor rehearsal room (approximately 4' by 8').

Return from first floor rehearsal room.

Appendix B
Summary of 2005 Pre-Feasibility Study Investigations, Site 11

Summary of 2005 Pre-Feasibility Study Investigations at Site 11 School of Music Plating Shop, Naval Amphibious Base Little Creek, Virginia Beach, Virginia

PREPARED FOR: NAB Little Creek Partnering Team

PREPARED BY: CH2M HILL

DATE: February 9, 2006

Background

This Technical Memorandum presents a summary of pre-Feasibility Study (FS) investigations conducted at Site 11 School of Music Plating Shop at Naval Amphibious Base (NAB) Little Creek, Virginia Beach, Virginia. Site 11 is a volatile organic compound (VOC) groundwater plume associated with a former Music Plating Shop (Building 3651) neutralization tank. A Supplemental Remedial Investigation (SRI) was completed in June 2004. As part of development of the Feasibility Study (FS) additional data needs were identified. In March 2005 a sampling event was completed to provide a current complete round of groundwater data. An additional sampling event was conducted in October 2005 to better define site characteristics associated with in situ remedial design technologies. This technical memorandum documents results of the pre-FS investigations at Site 11.

Objectives

The objectives of the March 2005 investigation included:

- Installation of two directional surficial aquifer wells beneath School of Music Building,
- Collection of groundwater samples from 26 existing monitoring wells and two newly installed monitoring wells, and
- Collection of a complete round of groundwater levels at all site wells.

The objectives of the October 2005 investigation were:

- Collection of eight groundwater samples from seven existing monitoring wells and one Direct Push Technology (DPT) location and
- Collection of 17 soil samples at seven locations using DPT.

Methods

March 2005 and October 2005 Groundwater Sampling

In March 2005 groundwater samples were collected at 26 existing and two newly installed monitoring wells (Figure 1). In October of 2005 samples were collected at a total of seven monitoring wells and one Direct Push Technology (DPT) location (LS11-GP804) (Figure 1). Groundwater sampling was conducted using a peristaltic pump and low-flow purge method. Prior to sample collection, monitoring wells were purged until field water quality parameters (pH, conductivity, turbidity, dissolved oxygen (DO), temperature, oxidation/reduction potential (ORP), and salinity) stabilized. Results of the field water quality measurements were recorded in the field notebook and are provided in Table 1. The DPT groundwater sample was collected by advancing a stainless steel groundwater sampling tool to approximately 22 feet below ground surface (bgs), followed by purging to minimize turbidity to the maximum extent practical.

Groundwater samples were collected in laboratory prepared sample containers and analyzed at an offsite laboratory. The following parameters were analyzed in March and October: Target Compound List (TCL) volatile organic compounds (VOCs), total organic carbon (TOC), dissolved manganese, nitrate, nitrite, sulfate, methane, ethane, and ethene. Additionally, total and dissolved iron, total manganese, and sulfide were analyzed in March and chloride, alkalinity, and volatile fatty acids (VFAs) were analyzed in October. All dissolved inorganic samples were collected using an inline filter. Methane, ethane, ethene, and VOC bottles were filled completely to minimize aeration, and capped to prevent the entrapment of any air bubbles in the vial.

In addition to laboratory analysis, ferrous iron and sulfide were field analyzed using HACH test kits and DO was field analyzed using Chemets test kits during the October sampling event. Results were recorded in the field notebook.

Quality Control Samples

Quality assurance (QA)/quality control (QC) samples were collected during the field activities in order to evaluate field methodologies (duplicates), evaluate whether cross contamination had occurred during sampling or shipping (equipment and trip blanks), establish field ambient conditions (field blanks), and measure sample-specific interference due to sample matrix (matrix spike (MS)/matrix spike duplicates (MSD).

All samples were labeled with the predetermined identification number. Samples were packed on ice for overnight shipment to an off-site laboratory. Temperature blanks were included in each cooler to confirm sample temperatures were less than 4 degrees Celsius when received by the laboratory.

Field samples and their corresponding analytical tests were recorded on chains-of custody (COC). Upon receipt of the samples by the laboratory, a comparison to the field information was made to determine if the samples, including the QA/AC samples, were documented correctly.

Decontamination and Investigation Derived Waste Procedures

All non-disposable sampling equipment, such as the direct push stainless steel rods and well screen, were decontaminated immediately after each use in accordance with applicable standard operating procedures (SOPs) included with the Master Project Plans (MPP) Field Sampling Plan (FSP) checklist (CH2M HILL, August 2000). Investigation derived waste (IDW) generated during field activities, including purge water and decontamination fluids, was containerized in 55-gallon drums. The 55-gallon drums were properly labeled and were stored at a location designated by NAVFAC and NAB Little Creek prior to disposal at an approved facility.

March 2005—Monitoring Well Installation

Two directional wells (LS11-MW36D and LS11-MW37D) were installed in the shallow aquifer using 4 ¼" hollow stem augers. The wells were installed around the perimeter of Building 3602 (Figure 1) at a 45° angle to better determine the extent of the VOC plume existing beneath Building 3602. Monitoring well construction diagrams and boring logs are provided in Attachment A.

Monitoring wells were constructed of 2-inch inner diameter, Schedule 40, polyvinyl chloride (PVC) screen and riser. Well screens consisted of machine slotted (0.01-inch) PVC, were pre-packed with filter sand, and were placed in the entire length of the water column and set at the top of the Yorktown Confining Unit. A 2 foot bentonite layer was placed at the top of the sand pack. Following hydration of the bentonite layer, a cement-bentonite grout was placed in the remaining annular space. The monitoring wells were completed flush to ground surface with a watertight steel cover. A locking watertight cap was placed on the PVC pipe and the monitoring wells were marked with an identification numbers.

The newly installed wells were developed using a combination of surging throughout the well screen and pumping until the physical and chemical parameters of the discharge water met the requirements discussed in the Groundwater Sampling Section above.

March 2005—Water Level Survey

To obtain the most consistent water level measurements, all water levels were taken concurrently on the last day of the investigation (April 1, 2005). Prior to taking water level measurements, the well cap was opened and the well was allowed to re-equilibrate. Top of casing elevations were used in conjunction with depth to water information to compute water table elevations. The station identification (ID) and depth to water below top of the PVC well casing were recorded in the field book. The results of the water level survey are summarized in Figure 2, Table 2.

October 2005—Soil Sampling

Using DPT, 19 soil samples were collected at various depths from seven locations (Figure 1, Table 3). Soil samples were collected continuously to the depth of the Yorktown Confining Unit (approximately 23 feet below ground surface (bgs)) using clean, 4-foot, disposable acetate sleeves. Soil boring logs are provided in Attachment A. Soil descriptions including grain size, Unified Soil Classification System (USCS) group symbol, color (according to the Munsell Soil Color Chart), moisture content, density, and hardness were recorded in the field notebook. A photoionization detector (PID) was used to field screen soils. Head space PID readings were collected from each two-foot sample interval in order to better determine the interval that contained the highest PID reading. A composite sample from each two-foot interval was placed in a 1-quart Ziploc bag. After a period of 5 to 10 minutes, a small opening large enough to accommodate the PID probe was made in the seal of the bag in order to measure concentrations while minimizing escape of volatiles. PID readings were recorded in the field notebook, and samples with the highest PID readings were submitted for laboratory analysis. Samples were collected from the following three depth intervals:

- **Upper Columbia (UC)**—These samples were collected from the shallow portion of the Columbia Aquifer just below the water table or within the two-foot interval at approximately 8 ft to 16 ft bgs.
- **Lower Columbia (LC)**—These samples were collected from the two-foot interval within the lower five-feet of the Columbia Aquifer just above the Yorktown Confining Unit.
- **Yorktown Confining Unit (YC)**—These samples were collected in the first one to two feet of the Yorktown Confining Unit.

Sample IDs included UC, LC, or YC to designate the depth at which the sample was collected.

Humidity associated with rainy conditions during the sampling event limited the use of the PID. When the interval of soil containing the highest VOC concentrations could not be established using the PID, the soil sample was collected from the bottom two feet of the specified depth interval.

Soil samples were collected for the following analysis: VOCs, TOC, total oxidant demand (TOD), and microbial analysis [*Dehalococcoides* (DHC), *Dehalobacter* (DHB), a functional gene associated with DHC strain BAV1 (BAV1 R-Dase), and phospholipid fatty acids (PLFAs)]. In order to preserve organic materials in soils, grab samples were collected for VOC and TOD analysis. The interval of soil collected for TOC and microbial analysis was homogenized in a stainless steel bowl prior to placement in sample jars. Soil samples collected for geotechnical analysis (grain size, bulk density, and porosity) were collected in acetate sleeves, capped on the ends, and sent to the laboratory. Soil samples collected for laboratory analysis were stored, transported, and tracked using the same procedures described above for groundwater samples.

Analytical Results

The overall objective of these investigations is to provide the information necessary to select the remedial alternatives identified in the FS. The results of the investigations are presented below.

Analytical groundwater results are consistent between the March and October sampling events. A summary of the data is provided in Table 4 and a complete data set is provided in Attachment B. The generally low concentrations of DO, ORP, and nitrate, and the generally elevated concentrations of ferrous iron suggest the aquifer is a reduced environment (Tables 1 and 4). Constituents with concentrations exceeding the maximum contaminant level

(MCL) include the following VOCs: 1,1,1-trichloroethane (TCA), 1,1,2-TCA, 1,1-dichloroethene (DCE), 1,2-dichloroethane (DCA), 1,2-DCE (cis and trans), 1,2-dichloropropane, carbon tetrachloride, methylene chloride, trichloroethene (TCE), and vinyl chloride (VC) (Table 5). Total VOC concentrations exceed 100,000 µg/L (micrograms/liter) in the source area. Isoconcentration lines for total VOCs are shown in Figure 3.

Soil analytical results are provided in Attachment B and are summarized in Table 5. VOC concentrations in soils collected from the upper portion of the Columbia Aquifer were less than 30 µg/L, with the exception of LS11-SB805 which had a TCE concentration of 55 µg/L. From those samples collected in the lower portion of the Columbia Aquifer, the greatest VOC concentration was 600 µg/L for cis-1,2-DCE from sample location LS11-SB801. The greatest VOC concentrations were found in the upper portion of the Yorktown Confining Unit and exceeded 10,000 µg/L, with the highest concentration found at sample location LS11-SB802 (25,000 µg/L TCE). In the samples collected from the upper portion of the Yorktown Confining Unit, TOC concentrations were equal to or greater than 10,000 mg/kg (milligram/kilogram). Although TOC concentrations are greater than would be expected given the soil characteristics, these elevated concentrations can be attributed to the in situ use of cyclodextrin during the 2002 pilot study.

Microbial Insights conducted analysis of VFAs in groundwater and DHC, DHB, BAV1 R-Dase, and PLFAs in soil to evaluate microbial activity at the site. The results are provided in Attachment B. The presences of VFAs, DHC, DHB, BAV1 R-Dase, and bacterial biomass exceeding 1×10^6 cells/milliliter (mL) indicates the presence of healthy bacterial populations including those capable of reductive dechlorination.

TOD analysis was completed by Redox Tech using sodium persulfate as the oxidant. The results of the analysis are presented in Table 6. Oxidant demands for the lower portion of the Columbia Aquifer ranged from 1.9 to 3.7 grams/kilogram (g/kg) of sodium persulfate. The upper portion of the Yorktown Confining Unit has oxidant demands ranging from 11 to greater than 19.5 g/kg of sodium persulfate. These values are not unexpected based on the elevated TOC concentrations in soil. Consequently, treatment with a technology such as *in situ* chemical oxidation would require an excessive amount of oxidant to overcome the site TOD.

Geotechnical analysis was conducted on two samples from the lower portion of the Columbia Aquifer and two samples from the upper portion of the Yorktown Confining Unit. Complete results, including the grain size distribution figures, are provided in Attachment B. The samples from the lower portion of the Columbia Aquifer were classified as silty sand (SM) and sand (SP), with a moisture content of 19.6 percent and 18.5 percent, and a porosity of 49.4 percent and 38.0 percent, respectively. The samples from the upper portion of the Yorktown Confining Unit were classified as sandy silt (ML) and silty clay (CH), with a moisture content of 43.0 percent and 55.9 percent, and a porosity of 52.0 percent and 60.6 percent, respectively.

Tables

Table 1
Water Quality Field Parameters (March and October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	LS11-MW01T	LS11-MW02S	LS11-MW03T	LS11-MW04D		LS11-MW05D		LS11-MW05S	LS11-MW06D	LS11-MW07D	LS11-MW08D	LS11-MW09D
Sample ID	LS11-MW01T-05A	LS11-MW02S-05A	LS11-MW03T-05A	LS11-MW04D-05A	LS11-MW04D-05D	LS11-MW05D-05A	LS11-MW05D-05D	LS11-MW05S-05A	LS11-MW06D-05A	LS11-MW07D-05A	LS11-MW08D-05A	LS11-MW09D-05A
Sample Date	04/01/2005	04/01/2005	03/31/2005	03/30/2005	10/10/2005	03/30/2005	10/10/2005	03/30/2005	03/30/2005	03/30/2005	03/30/2005	03/30/2005
Field Parameters												
Dissolved Oxygen (mg/L)	0.5	1.4	0.4	0.5	0.8	0.5	0	0.5	5.1	1	1.9	1.8
Depth to Water (ft)	5.35	3.83	3.29	6.35	6.42	5.27	5.43	4.87	3.75	5.85	6.96	6.11
ORP (mV)	2	101	-11	-68	-136	-183	-215	-60	163	229	287	173
Flow Rate (GPM)	0.052	0.066	0.052	0.066	0.053	0.066	0.079	0.066	0.066	0.066	0.066	0.066
Gallons Purged (GAL)	NA	NA	NA	2	2	2.5	4	1	1.5	2	2	2
Salinity (%)	0	0	0	0	0.03	0	0.02	0	0	0	0	0
pH	5.84	5.66	5.7	5.96	6.18	6.79	6.88	6.05	7.67	5.78	5.48	5.65
Specific Conductance (ms/cm)	0.374	0.361	0.306	0.629	0.639	0.529	0.515	0.472	0.371	0.176	0.169	0.326
Temperature (C)	14.7	12.8	13.9	17.6	21.97	15.6	20.06	13.4	16.8	16.8	15	15.8
Turbidity (NTU)	3.7	2.1	0	0	4.5	1.6	-0.1	42.1	0	0.4	4.7	1.1

Station ID	LS11-MW09D	LS11-MW10D		LS11-MW11D	LS11-MW13D	LS11-MW14D	LS11-MW17D	LS11-MW18Y	LS11-MW19Y	LS11-MW20Y	LS11-MW23D	
Sample ID	LS11-MW09D-05D	LS11-MW10D-05A	LS11-MW10D-05D	LS11-MW11D-05A	LS11-MW13D-05A	LS11-MW14D-05A	LS11-MW17D	LS11-MW18Y-05A	LS11-MW19Y-05A	LS11-MW20Y-05A	LS11-MW23D-05A	LS11-MW23D-05D
Sample Date	10/10/2005	03/29/2005	10/10/2005	03/29/2005	03/29/2005	03/29/2005	03/29/2005	03/29/2005	03/29/2005	03/30/2005	03/31/2005	10/10/2005
Field Parameters												
Dissolved Oxygen (mg/L)	1	2.4	1.5	2	3.3	1.6	1	6.6	0.7	0.5	0.5	0.5
Depth to Water (ft)	6.25	6.07	5.91	NA	NA	5.81	4.81	5.29	NA	3.89	4.8	5
ORP (mV)	-48	265	306	208	56	217	365	149	-59	-115	-331	-410
Flow Rate (GPM)	0.066	0.066	0.079	0.066	0.071	0.066	0.066	0.066	0.066	0.066	0.046	0.053
Gallons Purged (GAL)	2.5	2.5	3	2	2.5	NA	2	NA	2	1.5	NA	5
Salinity (%)	0.01	0	0.01	0	0	0	0	0	0	0	0	0.02
pH	5.86	5.32	5.27	5.68	10.05	5.77	6.07	9.08	10.93	7	8.78	8.33
Specific Conductance (ms/cm)	0.348	0.225	0.242	0.143	0.245	0.275	0.405	0.286	0.952	0.446	0.394	0.502
Temperature (C)	20.95	17.3	22.95	21.88	17.7	18.1	15.7	17.8	19.3	15	14.6	20.11
Turbidity (NTU)	2.6	0.2	4.7	0	3.3	0	0	0	1.9	1.9	5.3	0.5

Station ID	LS11-MW24D			LS11-MW26D		LS11-MW27D	LS11-MW28D	LS11-MW29D	LS11-MW30D	LS11-MW36D	LS11-MW37D	LS11-GP804
Sample ID	LS11-MW24D-05A	LS11-MW25D-05A	LS11-MW25D-05D	LS11-MW26D-05A	LS11-MW26D-05D	LS11-MW27D-05A	LS11-MW28D-05A	LS11-MW29D-05A	LS11-MW30D-05A	LS11-MW36D-05A	LS11-MW37D-05A	LS11-GW804-LC
Sample Date	03/31/2005	03/31/2005	10/11/2005	03/31/2005	10/11/2005	03/31/2005	03/30/2005	03/31/2005	03/31/2005	04/01/2005	04/01/2005	10/07/05
Field Parameters												
Dissolved Oxygen (mg/L)	0.4	0.5	0.31	0.5	0.2	0.4	0.4	0.4	0.4	2	1.3	3.56
Depth to Water (ft)	5.55	5.12	5.22	4.61	4.77	4.88	5.18	5.1	4.7	8	10.41	NA
ORP (mV)	-151	-141	-167	-303	-221	-226	-197	-155	-286	151	156	-60
Flow Rate (GPM)	0.052	0.052	0.082	0.046	0.066	0.046	0.066	0.039	0.052	0.052	0.039	NA
Gallons Purged (GAL)	NA	NA	2	NA	NA	NA	1.5	NA	NA	NA	NA	NA
Salinity (%)	0.1	0.1	0.12	0	0.04	0	0.1	0	0	0	0	0.01
pH	6.44	6.63	6.65	7.93	7.04	7.22	7	6.59	7.53	5.37	5.42	5.25
Specific Conductance (ms/cm)	1.36	2.52	2.52	0.751	0.819	0.999	1.48	0.624	0.92	0.173	0.197	204
Temperature (C)	14.2	15.4	19.33	14.4	19.05	13.7	14.1	14	14.1	18.7	18.9	22.34
Turbidity (NTU)	13	0	1.8	0	8.3	0.5	0.2	0	1	3.8	4.1	423

Table 2
Water Level Survey (April 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

MONITORING WELL	TOP OF PVC (msl)	DEPTH TO WATER (ft)	GROUNDWATER ELEVATION (msl)
COLUMBIA AQUIFER WELLS			
LS11-MW01T	8.13	4.99	3.14
LS11-MW02S	6.97	3.81	3.16
LS11-MW03T	6.44	3.28	3.16
LS11-MW04D	9.2	6.09	3.11
LS11-MW05S	8.03	4.88	3.15
LS11-MW05D	8.36	5.22	3.14
LS11-MW06D	6.76	3.64	3.12
LS11-MW07D	8.86	5.79	3.07
LS11-MW08D	9.06	6.03	3.03
LS11-MW09D	8.88	6.06	2.82
LS11-MW10D	8.19	5.25	2.94
LS11-MW11D	9.89	7.32	2.57
LS11-MW13D	8.09	5.1	2.99
LS11-MW14D	8.57	5.66	2.91
LS11-MW17D	8.12	4.82	3.3
LS11-MW23D	7.59	4.46	3.13
LS11-MW24D	8.22	5.1	3.12
LS11-MW25D	7.92	4.78	3.14
LS11-MW26D	7.65	4.52	3.13
LS11-MW27D	7.6	4.46	3.14
LS11-MW28D	7.95	4.84	3.11
LS11-MW29D	8.05	4.93	3.12
LS11-MW30D	7.63	4.51	3.12
LS11-MW36D	9.17	*	NA
LS11-MW37D	9.00	*	NA
YORKTOWN AQUIFER WELLS			
LS11-MW18Y	8.75	4.88	3.87
LS11-MW19Y	8.38	4.35	4.03
LS11-MW20Y	7.05	3.26	3.79

msl = mean sea level
ft = feet
* = Directional wells. Exact depth to water is estimated.

Table 3
Location and DPT Sample Depths (October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Location	Sample	Depth
LS11-GP801	LS11-SB801-UC	6-8'bgs
	LS11-SB801-LC	18-19.5'bgs
	LS11-SB801-YC	20-22'bgs
LS11-GP802	LS11-SB802-UC	13-15'bgs
	LS11-SB802-LC	18-20'bgs
	LS11-SB802-YC	20.5-22.5'bgs
LS11-GP803	LS11-SB803-LC	18-20'bgs
LS11-GP804	LS11-SB804-LC	22-24'bgs
	LS11GW804-LC	22-24*
LS11-GP805	LS11-SB805-UC	10-12'bgs
	LS11-SB805-LC	24-28'bgs
	LS11-SB805-YC	24-28'bgs
LS11-GP806	LS11-SB806-UC	8-10'bgs
	LS11-SB806-LC	16-18bgs
	LS11-SB806-YC	20-22'bgs
LS11-GP807	LS11-SB807-UC	13-15'bgs
	LS11-SB807-LC	20-22'bgs
	LS11-SB807-YC	22-24'bgs

* Estimated sample interval

Table 4
Detects in Groundwater (March and October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	MCL-Groundwater	LS11-GP804	LS11-MW01T	LS11-MW02S	LS11-MW03T	LS11-MW04D		LS11-MW05D			LS11-MW05S	LS11-MW06D	LS11-MW07D	LS11-MW08D	LS11-MW09D		
Sample ID		LS11-GW804-LC	LS11-MW01T-05A	LS11-MW02S-05A	LS11-MW03T-05A	LS11-MW04D-05A	LS11-MW04D-05D	LS11-MW05D-05A	LS11-MW05D-05D	LS11-MW05DP-05D	LS11-MW05S-05A	LS11-MW06D-05A	LS11-MW07D-05A	LS11-MW08D-05A	LS11-MW09D-05A	LS11-MW09DP-05A	LS11-MW09D-05D
Sample Date		10/07/05	04/01/05	04/01/05	03/31/05	03/30/05	10/10/05	03/30/05	10/10/05	10/10/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05	10/10/05
Chemical Name																	
VOCs (UG/L)																	
1,1,1-Trichloroethane	200	2 J	1 J	10 U	10 U	320	64	190	28	27	10 U	10 U	10 U	1 J	280	240	42
1,1,2-Trichloroethane	5	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	10 U
1,1-Dichloroethane	–	2.5 J	35	10 U	10 U	600	340	280	160	180	10 U	10 U	10 U	2 J	150	150 J	54
1,1-Dichloroethene	7	10 U	2 J	10 U	10 U	140	77	29	8 J	8.8 J	10 U	1 J	10 U	4 J	220	240	30
1,2-Dichloroethane	5	10 U	10 U	10 U	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
1,2-Dichloroethene (total)	70	NA	25	5 J	2 J	3,500	NA	1,000	NA	NA	10 U	26	10 U	29	540	560	NA
1,2-Dichloropropane	5	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
2-Butanone	–	10 U	10 U	10 U	10 U	10 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
4-Methyl-2-pentanone	–	7.8 J	3 J	10 U	10 U	1,800	40 J	530	200 J	200 J	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Acetone	–	10 U	10 U	10 U	10 U	41	10 U	180	190	160	10 U	5 J	10 U	10 U	10 U	10 UJ	10 U
Bromodichloromethane	80	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Carbon tetrachloride	5	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Chloroethane	–	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Chloroform	80	10 U	10 U	10 U	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 J	2 J	10 U
Methyl acetate	–	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Methylcyclohexane	–	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Methylene chloride	5	10 U	1 B	1 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 B	10 U	10 U	10 U	1 B	10 U
Toluene	1,000	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U
Trichloroethene	5	22	21	10 U	10 U	29	8.8 J	10 U	10 U	10 U	10 U	30	10 U	20	1,500	1,400	140
Vinyl chloride	2	10 U	49	1 J	10 U	74	100 J	400	170 J	180 J	10 U	6 J	10 U	10 U	10 U	10 UJ	10 U
cis-1,2-Dichloroethene	70	15	25	5 J	2 J	3,500	1,200	1,000	310	320	10 U	26	10 U	29	540	560	360
trans-1,2-Dichloroethene	100	10 U	10 U	10 U	10 U	7 J	10 U	3 J	10 U	10 U	10 U	10 U	10 U	10 U	3 J	3 J	10 U
Total Metals (UG/L)																	
Calcium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	–	NA	NA	NA	7,620 J	15,900 J	NA	48,800 J	NA	NA	NA	NA	290 J	511 J	454 J	NA	NA
Magnesium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	–	NA	NA	NA	731 J	3,860	NA	7,180	NA	NA	NA	NA	640	52.7	972	NA	NA
Nickel	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)																	
Calcium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	–	NA	NA	NA	7,740 J	16,700	NA	47,100	NA	NA	NA	12.4 B	33.7 B	11.7 B	191	NA	NA
Magnesium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	–	93.6	NA	NA	810 J	3,930	3,590	7,260	6,900	6,830	NA	0.91 U	65.6	27	916	NA	2,300
Nickel	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	–	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wet Chemistry (MG/L)																	
Alkalinity	–	14	NA	NA	NA	NA	180	NA	94	96	NA	NA	NA	NA	NA	NA	70
Chloride	–	26	NA	NA	NA	NA	55 L	NA	44 L	38 L	NA	NA	NA	NA	NA	NA	31 L
Ethane	–	0.0062 U	NA	NA	0.01 U	0.01 U	0.0062 U	0.01 U	0.0062 U	0.0062 U	NA	NA	0.01 U	0.01 U	0.01 U	NA	0.0062 U
Ethene	–	0.0058 U	NA	NA	0.01 U	0.074	0.066	0.18	0.061	0.072	NA	NA	0.01 U	0.01 U	0.01 U	NA	0.0058 U
Methane	–	0.0063 J	NA	NA	0.19	0.49	0.32 J	0.56	0.15 J	0.17 J	NA	NA	0.081	0.069	0.037	NA	0.013 J
Nitrate	10	0.1 UJ	NA	NA	0.05 U	0.05 U	0.14	0.42	0.16	0.15	NA	NA	0.58	0.3	0.53	NA	0.1 U
Nitrite	1	NA	NA	NA	0.05 U	0.0056 J	NA	0.022 J	NA	NA	NA	NA	0.05 U	0.05 U	0.05 U	NA	NA
Sulfate	–	11	NA	NA	19	21	20	1.7	16	14	NA	NA	17	19	25	NA	30
Sulfide	–	NA	NA	NA	1 U	1 U	NA	1 U	NA	NA	NA	NA	0.25 J	1 U	1 U	NA	NA
Total organic carbon (TOC)	–	4	NA	NA	13	570	520	260	220	230	NA	NA	0.71 J	4.5	210	NA	180

Notes:
U- Analyte not detected
J- Reported value is estimated
UJ- Analyte not detected. Quantitation limit may be imprecise
L- Reported value is estimated
B- Possible blank contamination
NA- Not analyzed
Shading represents exceedance of MCL Screening Criteria
– No criteria established
"P" Identifier on sample ID indicates a duplicate sample
VOCs- Volatile Organic Compounds

Table 4
Detects in Groundwater (March and October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	MCL-Groundwater	LS11-MW10D		LS11-MW11D		LS11-MW13D	LS11-MW14D	LS11-MW17D	LS11-MW18Y	LS11-MW19Y		LS11-MW20Y	LS11-MW23D		LS11-MW24D	LS11-MW25D	
Sample ID		LS11-MW10D-05A	LS11-MW10D-05D	LS11-MW11D-05A	LS11-MW11DP-05A	LS11-MW13D-05A	LS11-MW14D-05A	LS11-MW17D-05A	LS11-MW18Y-05A	LS11-MW19Y-05A	LS11-MW19YP-05A	LS11-MW20Y-05A	LS11-MW23D-05A	LS11-MW23D-05D	LS11-MW24D-05A	LS11-MW25D-05A	LS11-MW25D-05D
Sample Date		03/29/05	10/10/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/30/05	03/31/05	10/10/05	03/31/05	03/31/05	10/11/05
Chemical Name																	
VOCs (UG/L)																	
1,1,1-Trichloroethane	200	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	84	7.4 J	50 U	32,000	27,000 L
1,1,2-Trichloroethane	5	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	10 U	50 U	2,000 U	14
1,1-Dichloroethane	--	3 J	3.9 J	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	760	1,300	10 J	12,000	12,000 L
1,1-Dichloroethene	7	34	58	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	14	17	8 J	2,700	3,900 L
1,2-Dichloroethane	5	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 J	2.7 J	50 U	2,000 U	10 U
1,2-Dichloroethene (total)	70	10 J	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000	NA	160	300,000	NA
1,2-Dichloropropane	5	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	22
2-Butanone	--	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	7 J	10 U	26 J	2,000 U	10 U
4-Methyl-2-pentanone	--	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	110	160 J	1,900	1,500 J	2,200 J
Acetone	--	5 J	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	140	10 U	51	1,500 J	1,100 J
Bromodichloromethane	80	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	10 U
Carbon tetrachloride	5	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	1,300 J
Chloroethane	--	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	970	2,000 U	10 U
Chloroform	80	1 J	1.4 J	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	10 U
Methyl acetate	--	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	10 U
Methylcyclohexane	--	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	2,000 U	2 J
Methylene chloride	5	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 B	10 U	12 B	2,800	7,100 L
Toluene	1,000	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1.3 J	50 U	2,000 U	16
Trichloroethene	5	280	370	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	7 J	13	50 U	2,000 U	1,200 J
Vinyl chloride	2	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	3,200	5,500	3,000	1,600 J	7,600 L
cis-1,2-Dichloroethene	70	10 J	12	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000	1,100	160	300,000	260,000 L
trans-1,2-Dichloroethene	100	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	13	11	50 U	550 J	300 J
Total Metals (UG/L)																	
Calcium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	--	187 J	NA	21.3 B	33.7 B	443 J	NA	NA	NA	NA	NA	NA	6,090 J	NA	NA	71,900 J	NA
Magnesium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	--	215	NA	90.1	99	8.6	NA	NA	NA	NA	NA	NA	51.4 J	NA	NA	8,880 J	NA
Nickel	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)																	
Calcium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	--	8 B	NA	7.73 U	7.73 U	11.5 B	NA	NA	NA	NA	NA	NA	472 J	NA	NA	67,000 J	NA
Magnesium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	--	51.2	128	61.1	62.5	1.4 B	NA	NA	NA	NA	NA	NA	35.3 J	142	NA	8,610 J	9,150
Nickel	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wet Chemistry (MG/L)																	
Alkalinity	--	NA	8.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	87	NA	NA	470
Chloride	--	NA	49 L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59 L	NA	NA	400
Ethane	--	0.01 U	0.0062 U	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.01 U	0.0062 U	NA	0.01	0.0062 U
Ethene	--	0.01 U	0.0058 U	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.42	0.46	NA	0.043	0.066 J
Methane	--	0.01 U	0.011 J	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.74	0.86 J	NA	0.32	0.37 J
Nitrate	10	1	0.18	1.8	NA	1.5	NA	NA	NA	NA	NA	NA	0.05 U	0.15	NA	0.05 U	0.14 L
Nitrite	1	0.05 U	NA	0.05 U	NA	0.054	NA	NA	NA	NA	NA	NA	0.014 J	NA	NA	0.14	NA
Sulfate	--	41	44	21	NA	13	NA	NA	NA	NA	NA	NA	5 U	0.1 U	NA	1 U	0.12
Sulfide	--	1.2	NA	1.2	NA	1	NA	NA	NA	NA	NA	NA	1 U	NA	NA	0.7 J	NA
Total organic carbon (TOC)	--	0.45 J	1 U	0.49 J	NA	2.4	NA	NA	NA	NA	NA	NA	120	230	NA	2,600	3,600

TCE
VC
trans

Notes:
U- Analyte not detected
J- Reported value is estimated
UJ- Analyte not detected. Quantitation limit may
L- Reported value is estimated
B- Possible blank contamination
NA- Not analyzed
Shading represents exceedance of MCL Screer
-- No criteria established
"P" Identifier on sample ID indicates a duplicate
VOCs- Volatile Organic Compounds

Table 4
Detects in Groundwater (March and October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Table 4
Detects in Groundwater

Station ID	MCL-Groundwater	LS11-MW26D		LS11-MW27D	LS11-MW28D	LS11-MW29D	LS11-MW30D	LS11-MW36D		LS11-MW37D
Sample ID		LS11-MW26D-05A	LS11-MW26D-05D	LS11-MW27D-05A	LS11-MW28D-05A	LS11-MW29D-05A	LS11-MW30D-05A	LS11-MW36D-05A	LS11-MW36DP-05A	LS11-MW37D-05A
Sample Date		03/31/05	10/11/05	03/31/05	03/30/05	03/31/05	03/31/05	04/01/05	04/01/05	04/01/05
Chemical Name										
VOCs (UG/L)										
1,1,1-Trichloroethane	200	17	190 J	10 UJ	12,000	1,400	2,100	10 U	10 U	10 U
1,1,2-Trichloroethane	5	10 U	10 U	10 UJ	15	100 U	200 U	10 U	10 U	10 U
1,1-Dichloroethane	--	170	940 L	520	4,000	920	2,600	10 U	10 U	4 J
1,1-Dichloroethene	7	1 J	10 J	10 UJ	2,700	87 J	390	10 U	10 U	70
1,2-Dichloroethane	5	10 U	1.9 J	10 UJ	23	100 U	200 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	70	19	NA	25 J	60,000	3,600	47,000	10 U	10 U	3 J
1,2-Dichloropropane	5	10 U	10 U	10 UJ	8 J	100 U	200 U	10 U	10 U	10 U
2-Butanone	--	4 J	45 J	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
4-Methyl-2-pentanone	--	640 J	1,600 L	37 J	3,000	1,000	610	10 U	10 U	10 U
Acetone	--	51	820 L	10 UJ	370	240	340	10 U	10 U	10 U
Bromodichloromethane	80	10 U	10 U	10 UJ	10 U	100 U	200 U	2 J	2 J	10 U
Carbon tetrachloride	5	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Chloroethane	--	10 U	10 U	32 J	10 U	100 U	200 U	10 U	10 U	10 U
Chloroform	80	10 U	10 U	10 UJ	13	100 U	200 U	6 J	6 J	10 U
Methyl acetate	--	10 U	16 J	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methylcyclohexane	--	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methylene chloride	5	10 U	10 U	2 B	470	23 B	140 J	10 U	10 U	2 B
Toluene	1,000	10 U	1.6 J	10 UJ	5 J	100 U	200 U	4 J	2 J	5 J
Trichloroethene	5	1 J	6.7 J	2 J	24	100 U	53 J	3 J	2 J	230
Vinyl chloride	2	280 J	3,500 L	140 J	2,300	4,400	5,400	10 U	10 U	10 U
cis-1,2-Dichloroethene	70	19	330 L	25 J	60,000	3,000	47,000	10 U	10 U	3 J
trans-1,2-Dichloroethene	100	10 U	5.9 J	10 UJ	450	100 U	120 J	10 U	10 U	10 U
Total Metals (UG/L)										
Calcium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	200	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	--	10,500 J	NA	NA	NA	NA	NA	174 J	142 J	630 J
Magnesium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	--	871 J	NA	NA	NA	NA	NA	61.4 J	58.2 J	160 J
Nickel	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)										
Calcium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	--	9,120 J	NA	NA	NA	NA	NA	19.2 B	17.7 B	39.9 B
Magnesium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	--	1,110 J	3,340	NA	NA	NA	NA	52.9 J	53.1 J	156 J
Nickel	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	--	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wet Chemistry (MG/L)										
Alkalinity	--	NA	250	NA	NA	NA	NA	NA	NA	NA
Chloride	--	NA	66	NA	NA	NA	NA	NA	NA	NA
Ethane	--	0.01 U	0.0062 U	NA	NA	NA	NA	0.01 U	NA	0.01 U
Ethene	--	0.15	0.44 J	NA	NA	NA	NA	0.01 U	NA	0.01 U
Methane	--	4.9	5.8 J	NA	NA	NA	NA	0.01 U	NA	0.076
Nitrate	10	0.05 U	0.12 L	NA	NA	NA	NA	0.046 J	NA	0.028 J
Nitrite	1	0.008 J	NA	NA	NA	NA	NA	0.05 U	NA	0.05 U
Sulfate	--	1 U	0.24	NA	NA	NA	NA	11	NA	12
Sulfide	--	1 U	NA	NA	NA	NA	NA	1 U	NA	1 U
Total organic carbon (TOC)	--	290	720	NA	NA	NA	NA	1.3	NA	0.55 J

Notes:
U- Analyte not detected
J- Reported value is estimated
UJ- Analyte not detected. Quantitation limit may
L- Reported value is estimated
B- Possible blank contamination
NA- Not analyzed
Shading represents exceedance of MCL Screer
-- No criteria established
"P" Identifier on sample ID indicates a duplicate
VOCs- Volatile Organic Compounds

Table 5
Detections in Soil (October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	LS11-GP801			LS11-GP802			LS11-GP803	LS11-GP804	
Sample ID	LS11-SB801-UC	LS11-SB801-LC	LS11-SB801-YC	LS11-SB802-YC	LS11-SB802-LC	LS11-SB802-UC	LS11-SB803-LC	LS11-SB804-LC	LS11-SB804P-LC
Sample Date	10/07/05	10/07/05	10/07/05	10/08/05	10/08/05	10/08/05	10/08/05	10/07/05	10/07/05
Chemical Name									
Volatile Organic Compounds (UG/KG)									
1,1,1-Trichloroethane	12 U	93	16 U	15 J	16 J	12 U	12 U	12 U	13 U
1,1-Dichloroethane	2.5 J	38	2,100	3,000 J	7.3 J	7.1 J	4.9 J	12 U	13 U
1,1-Dichloroethene	12 U	5 J	210	620 J	11 U	12 U	12 U	12 U	13 U
1,2-Dichloroethane	12 U	12 U	16 U	6.8 J	11 U	12 U	12 U	12 U	13 U
2-Butanone	12 U	13	16 U	17 U	11 U	12 U	12 U	12 U	13 U
4-Methyl-2-pentanone	12 U	200	16 U	72 J	14	8.5 J	12 U	12 U	13 U
Acetone	12 U	510 J	16 J	210 J	11 U	12 U	12 U	12 U	13 U
Carbon disulfide	12 U	12 U	21	40	11 U	12 U	12 U	12 U	13 U
Chloroethane	12 U	12 U	11 J	34	11 U	12 U	12 U	12 U	13 U
Ethylbenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Methylene chloride	12 U	22 J	530 J	240	11 U	12 U	12 U	12 U	13 U
Toluene	12 U	12 U	16 U	3.7 J	11 U	12 U	12 U	12 U	13 U
Trichloroethene	6 J	22 J	18,000	25,000 J	17 J	18	23	3 J	25
Vinyl chloride	12 U	7.3 J	16 U	140	11 U	12 U	12 U	12 U	13 U
Xylene, total	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
cis-1,2-Dichloroethene	11 J	600	130 J	8,100 J	130 J	26	16	8.2 J	9.9 J
trans-1,2-Dichloroethene	12 U	12 U	16 U	42	11 U	12 U	12 U	12 U	13 U
Wet Chemistry (MG/KG)									
% Solids	86	86	63	60	90	83	85	82	77
Total organic carbon (TOC)	NA	950	12,000	22,000	1,300	NA	NA	NA	NA

NA - Not analyzed
J - Reported value is estimated
U - Analyte not detected

Table 6
Total Oxidant Demand (TOD) (October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Well Number	Oxidant (g/kg)
LS11-SB801-LC	3.7 Na persulfate
LS11-SB801-YC	> 19.5 Na persulfate
LS11-SB805-LC	1.9 Na persulfate
LS11-SB805-YC	11 Na persulfate
LS11-SB806-LC	2.5 Na persulfate
LS11-SB806-YC	12 Na persulfate

Figures

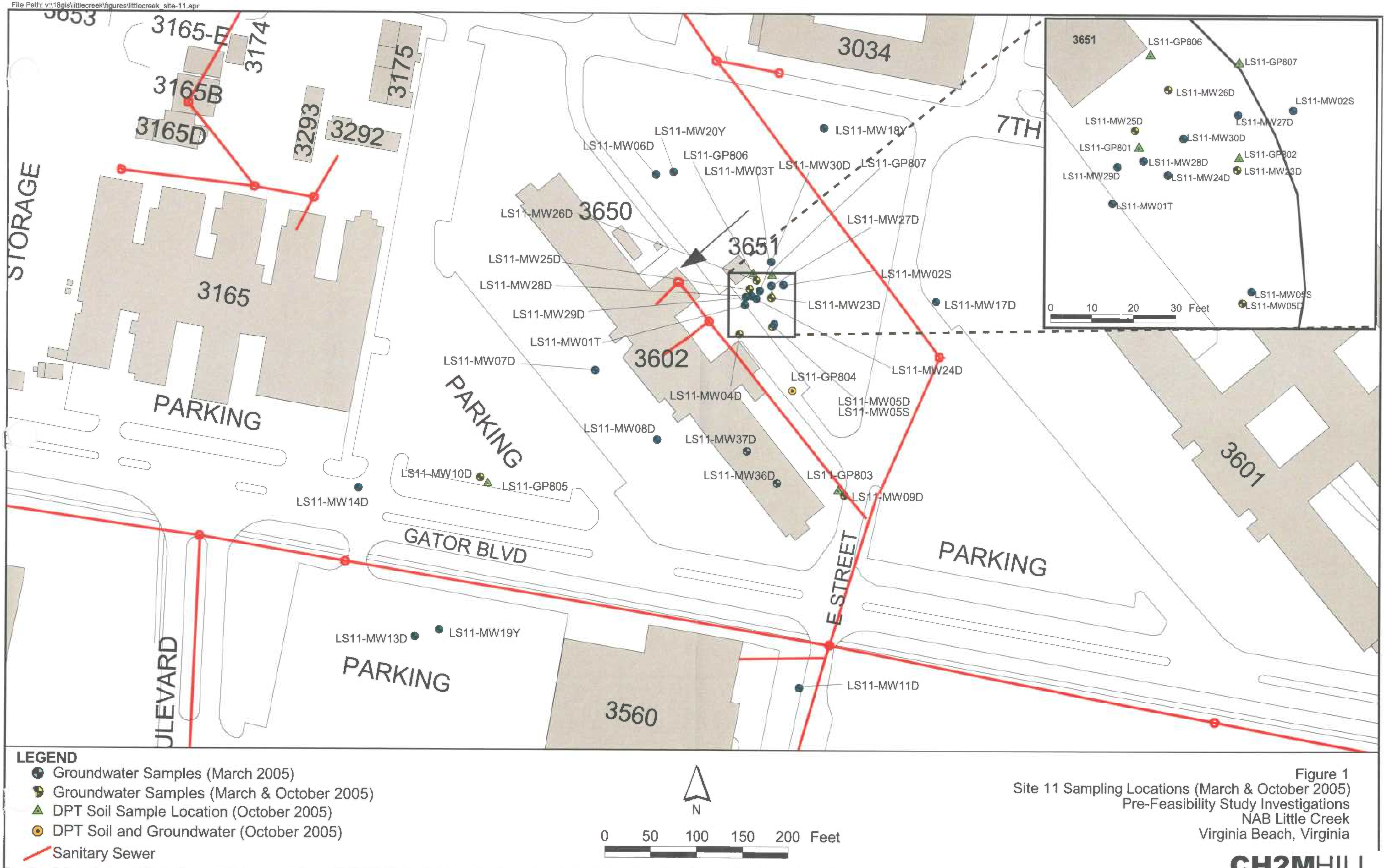

Figure 1
Site 11 Sampling Locations (March & October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

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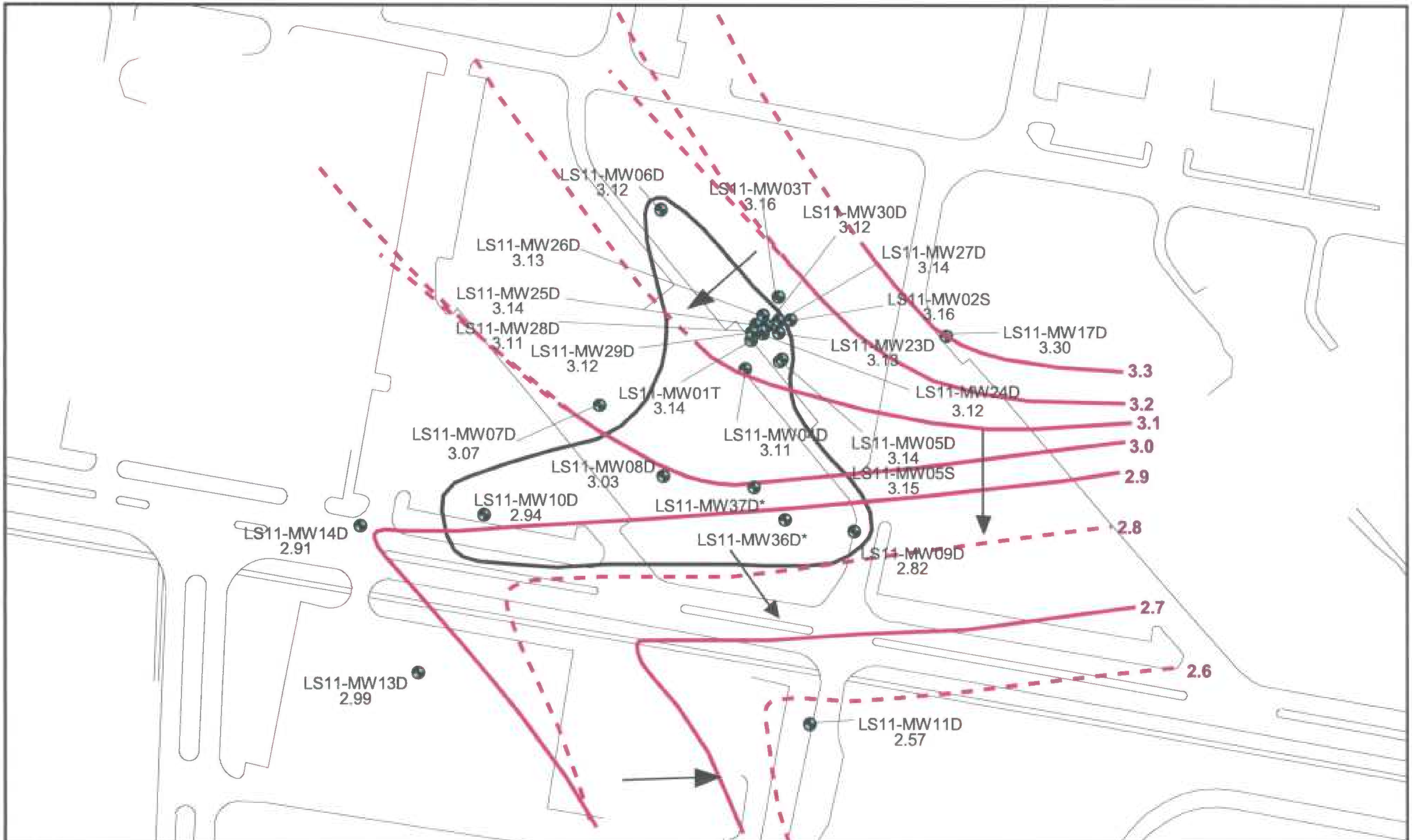
File Path: v:\18gis\littlecreek\figures\littlecreek_site-11.apr



LEGEND

- Monitoring Well
- Groundwater Flow Direction
- * Directional Wells. Exact Depth to Water is Estimated.

N

0 75 150 Feet

Figure 2
Site 11 Potentiometric Surface Map
Pre-Feasibility Study Investigations, April 2005
NAB Little Creek
Virginia Beach, Virginia

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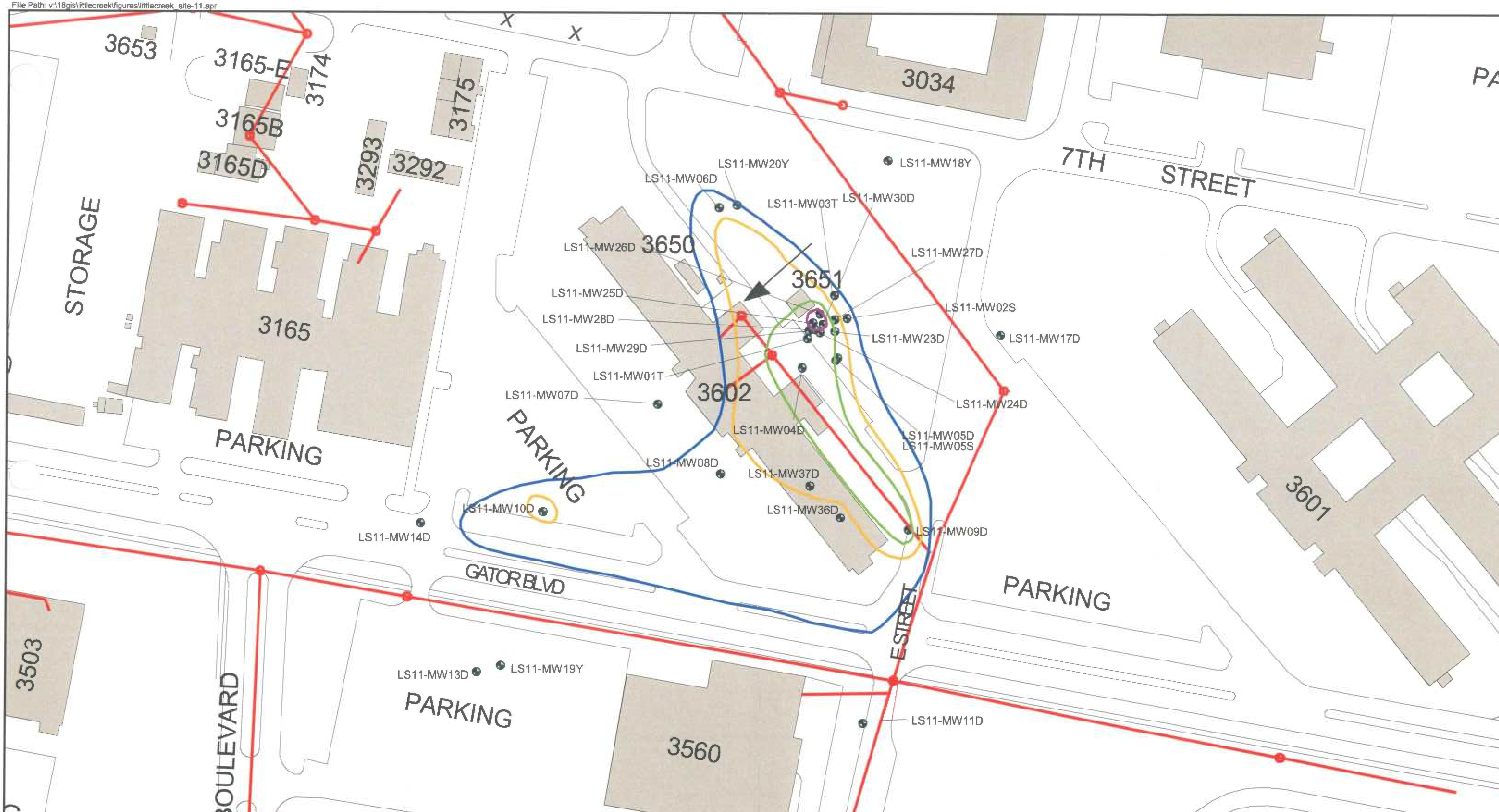
File Path: v:\18gis\littlecreek\figures\littlecreek_site-11.apr



LEGEND

- Monitoring Well
- Sanitary Sewer
- Groundwater Flow Direction

Total VOC Concentration (ug/L)

- 1 - 100
- 100 - 1,000
- 1,000 - 100,000
- 100,000 +

Note: The groundwater isoconcentration map depicts deep Columbia aquifer concentrations at Site 11.

Isoconcentrations are based on 2005 Analytical Results.

N

0 50 100 150 200 Feet

Figure 3
Site 11 Total VOCs in Groundwater (March & October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

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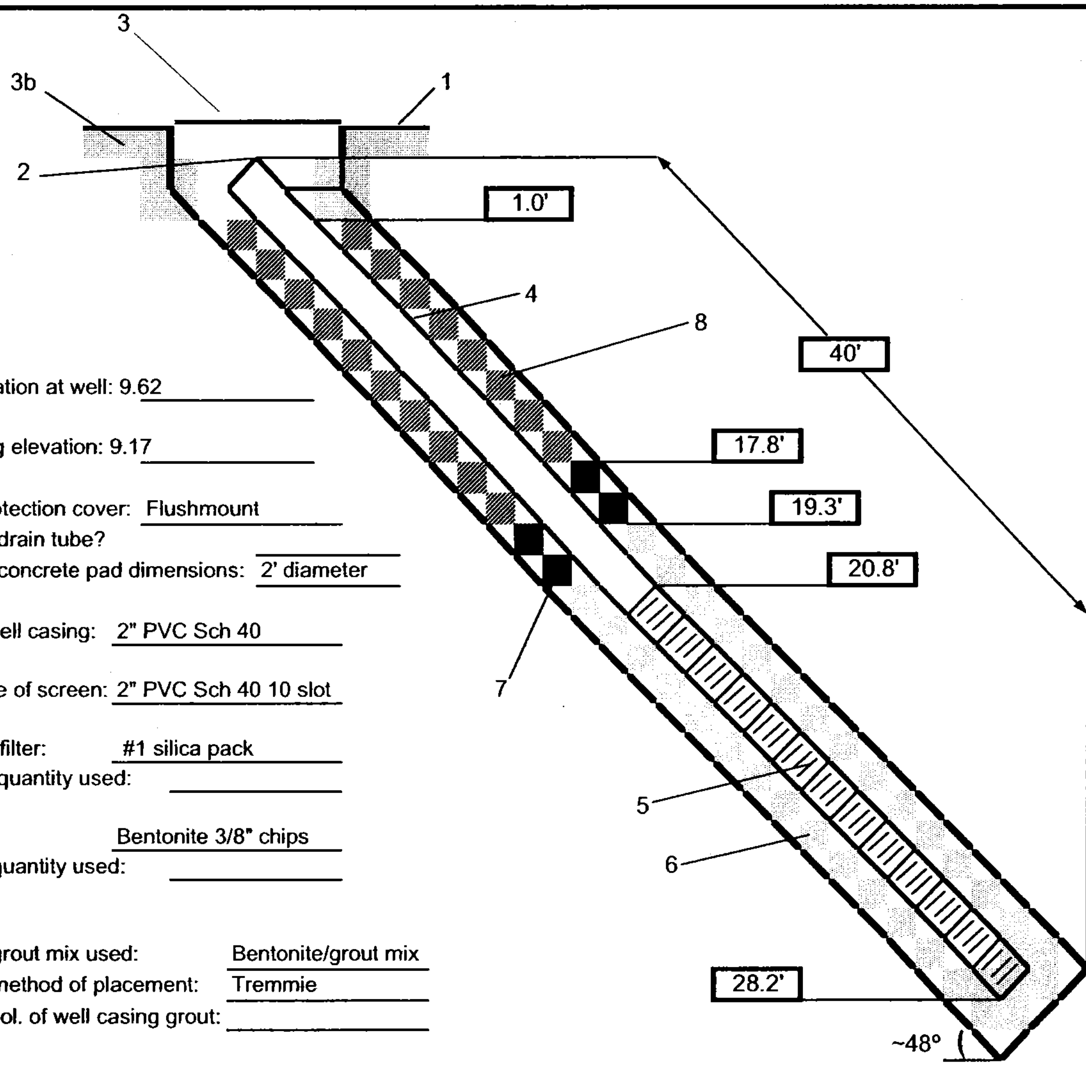
Attachment A

CH2MHILL	Project Number 157234.FS.DR	Well Number LS11-MW36D Sheet 1 of 1

DIRECTIONAL WELL COMPLETION DIAGRAM

PROJECT: NAB Little Creek LOCATION: Site 11
DRILLING CONTRACTOR: Parratt-Wolff NORTHING: 3500880.96 EASTING:12169560.79
DRILLING METHOD AND EQUIPMENT USED: 41/4 Hollow Stem Auger
WATER LEVELS: START: 3/28/2005 1630 END: 3/29/2005 1250 LOGGER: C. White



1 - Ground elevation at well: 9.62

2 - Top of casing elevation: 9.17

3 - Wellhead protection cover: Flushmount
a - drain tube?
b - concrete pad dimensions: 2' diameter

4 - Dia/type of well casing: 2" PVC Sch 40

5 - Type/slot size of screen: 2" PVC Sch 40 10 slot

6 - Type screen filter: #1 silica pack
a - quantity used:

7 - Type of seal: Bentonite 3/8" chips
a) quantity used:

8 - Grout:
a) grout mix used: Bentonite/grout mix
b) method of placement: Tremmie
c) vol. of well casing grout:

Development method: Whale Pump

Development time: 53 minutes

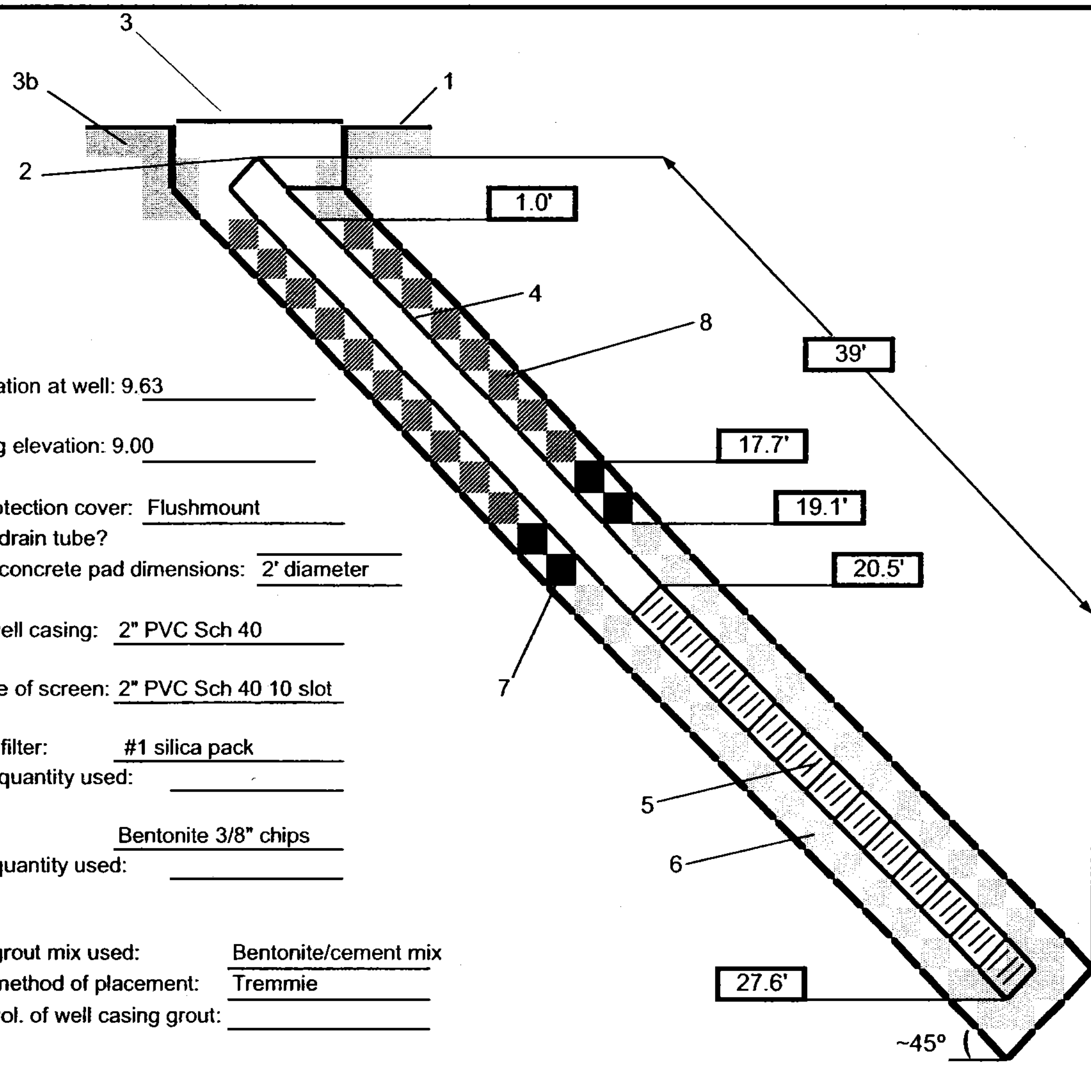
Estimated purge vol: 65 gallons

Comments: Well set at an angle of ~48 degrees

CH2MHILL	Project Number 157234.FS.DR	Well Number LS11-MW37D Sheet 1 of 1

DIRECTIONAL WELL COMPLETION DIAGRAM

PROJECT: NAB Little Creek   LOCATION: Site 11
DRILLING CONTRACTOR: Parratt-Wolff   NORTHING: 3500804.25   EASTING: 12169544.24
DRILLING METHOD AND EQUIPMENT USED: 4 1/4" Hollow Stem Auger
WATER LEVELS: START: 3/30/2005 0912   END: 3/30/2005 1242   LOGGER: C. White



1 - Ground elevation at well: 9.63

2 - Top of casing elevation: 9.00

3 - Wellhead protection cover: Flushmount
a - drain tube?
b - concrete pad dimensions: 2' diameter

4 - Dia/type of well casing: 2" PVC Sch 40

5 - Type/slot size of screen: 2" PVC Sch 40 10 slot

6 - Type screen filter: #1 silica pack
a - quantity used:

7 - Type of seal: Bentonite 3/8" chips
a) quantity used:

8 - Grout:
a) grout mix used: Bentonite/cement mix
b) method of placement: Tremmie
c) vol. of well casing grout:

Development method: Whale Pump

Development time: 110 minutes

Estimated purge vol: 45 gallons

Comments: Well set at an angle of ~45 degrees

PROJECT NUMBER	BORING NUMBER	
157234.FS.FR	LS11-MW36D	SHEET 1 OF 2

CH2MHILL

SOIL BORING LOG

PROJECT : CTO-021 DRILLING CONTRACTOR : Parratt-Wolff LOCATION : NAB Little Creek Site 11

ELEVATION : 9.17 NORTHING: 3500880.96 EASTING: 12169560.79

DRILLING METHOD AND EQUIPMENT USED :4 1/4" Hollow Stem Auger - Directional Drilling at 45 degree angle

WATER LEVELS : START: 3/28/05 1225 END: 3/28/05 1600 LOGGER : J. Butler/C. White

Length of Auger Drilled @ 45° (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
5						
10	10-14'	42"	1		10.0'-13.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose	PID = 0.0ppm
15	14-18'	48"	2		13.0'-14.0' Silty coarse SAND, SW, olive yellow (2.5Y 6/6), saturated, loose 14.0'-18.0' Coarse SAND, SW, olive yellow (2.5Y 6/6), some silt, saturated, loose	PID = 0.0ppm
	18-22'	48"	3		18.0'-22.0' Coarse silty SAND, SW, olive yellow (2.5Y 6/6), saturated, loose	PID = 0.0ppm
20						
	22-26'	48"	4		22.0'-23.0' Silty SAND, SM, olive yellow (2.5Y 6/6), saturated, loose 23.0'-26.0' Gravelly SAND, SW, olive yellow (2.5Y 6/6), saturated, loose, dark brown (2.5Y 4/3) lense 25.0' 25.5'	PID = 0.0ppm
25						
	26-30'	48"	5		26.0'-27.0' Coarse SAND, SW, olive yellow (2.5Y 6/6), saturated, loose 27.0'-29.0' Silty SAND, SM, light brownish grey (2.5Y 6/2), saturated, loose	PID = 0.0ppm

	PROJECT NUMBER	BORING NUMBER	
CH2MHILL	157234.FS.FR	LS11-MW36D	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : CTO-021 DRILLING CONTRACTOR : Parratt-Wolff LOCATION : NAB Little Creek Site 11

ELEVATION : 9.17 NORTHING: 3500880.96 EASTING: 12169560.79

DRILLING METHOD AND EQUIPMENT USED :4 1/4" Hollow Stem Auger - Directional Drilling at 45 degree angle

WATER LEVELS : START: 3/28/05 1225 END: 3/28/05 1600 LOGGER : J. Butler/C. White

Length of Auger Drilled @ 48° (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
30	30-34'	48"	6		29.0'-30.0' Silty SAND, SM, light yellowish grey (2.5Y 6/3), saturated, loose 30.0'-32.5' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose 32.5'-34.0' Medium silty SAND, SM, light yellowish brown (2.5Y 6/4), moderately dense	PID = 0.0ppm
35	34-38'	48"	7		34.0'-35.5' Medium SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose, 1" clay layer at 34.5' 35.5' 37.5' Coarse SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose	PID = 0.0ppm
40	38-42'	48"	8		37.5'-38.0' Medium SAND, SC, light yellowish brown (2.5Y 6/4), saturated, medium dense 38.0'-40.0' Medium SAND, SC, light yellowish brown (2.5Y 6/4), saturated, medium dense, mottling 40.0'-41.0' Clayey SILT, CL, strong brown (7.5YR 5/6), saturated 41.0-42.0 Silty CLAY, CL, very dark grey (GLEY 1 3/N), saturated, medium dense	PID = 0.0ppm Monitoring well LS11-MW36D installed
45					End of boring @ 42.0' of rods **Note: Boring completed at ~48° angle, thus the boring dept is indicative of the length of auger (not vertical distance bgs).**	
50						

CH2MHILL	PROJECT NUMBER 157234.FS.FR
BORING NUMBER LS11-MW37D	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : CTO-021 | DRILLING CONTRACTOR : Parratt-Wolff | LOCATION : NAB Little Creek Site 11

ELEVATION :9.00 | NORTHING: 3500804.25 | EASTING: 12169544.24

DRILLING METHOD AND EQUIPMENT USED :4 1/4" Hollow Stem Auger- Directional Drilling at 45 degree angle

WATER LEVELS : | START: 3/29/05 1705 | END: 3/30/05 0912 | LOGGER : C. White

Length of Auger @ 45°(FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
5						
10	10-14'	42"	1		10.0' 12.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), moist, loose, some coarse sand 12.0'-12.5' Silty SAND, SM, olive yeloow (2.5Y 6/6), moist, loose 12.5'-13.5' Silty SAND, SM, light yellowish brown (2.5Y 6/4), moist, loose, some coarse sand 13.5'-14.0' No Recovery	PID = 0.0ppm
15	14-18'	48"	2		14.0'-18.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose, some coarse sand	PID = 0.0ppm
	18-22'	48"	3		18.0'-22.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose, some coarse sand	PID = 0.0ppm
20						
	22-26'	48"	4		22.0-23.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose 23.0'-26.0' Silty SAND, SM, yellowish brown (10YR 5/6), saturated, loose, some coarse sand	PID = 0.0ppm
25						
	26-30'	36"	5		26.0'-28.0' Silty SAND, SM, yellowish brown (10YR 5/6), saturated, loose, some coarse sand 28.0'-29.0' Silty SAND, SM, yellowish brown (10YR 5/6), saturated, loose	PID = 0.0ppm

CH2MHILL	PROJECT NUMBER 157234.FS.FR	BORING NUMBER LS11-MW37D	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : CTO-021 DRILLING CONTRACTOR : Parratt-Wolff LOCATION : NAB Little Creek Site 11

ELEVATION :9.00 NORTHING: 3500804.25 EASTING: 12169544.24

DRILLING METHOD AND EQUIPMENT USED :4 1/4" Hollow Stem Auger- Directional Drilling at 45 degree angle

WATER LEVELS : START: 3/29/05 1705 END: 3/30/05 0912 LOGGER : C. White

Length of Auger @ 45°(FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
					29.0'-30.0' No Recovery	
30	30-34'	48"	6		30.0'-33.0' Clayey SAND, SC, dark grey (2.5Y 4/1), saturated, medium dense, some organics	PID = 0.0ppm
					33.0'-34.0' Silty SAND, SM, grey (2.5Y 5/1), saturated, loose	
35	34-38'	48"	7		34.0'-35.0' SAA 35.0'-36.0' Clayey SAND, SC, dark grey (2.5Y 4/1), saturated, medium dense 36.0'-38.0' Silty SAND, SM, light yellowish brown (2.5Y 6/4), saturated, loose, some coarse sand	PID = 0.0ppm
40	38-42'	48"	8		38.0'-39.5' Clayey SAND, SC, light yellowish brown (2.5Y 6/4), moist, medium dense 39.5'-42.0' CLAY, CL, greenish grey (GLEY 1 5/5GY), moist, dense, trace silt	PID = 0.0ppm Monitoring well LS11-MW37D installed
45					End of boring @ 42.0' of rods **Note: Boring completed at ~45° angle, thus the boring length is indicative of the length of auger.**	
50						

PROJECT NUMBER	BORING NUMBER	
329752.SI.WP	LS11-GP801	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek | DRILLING CONTRACTOR : Parratt-Wolff | LOCATION : Site 11

ELEVATION :9.50 | NORTHING: 3500881.61 | EASTING: 12169477.18

DRILLING METHOD AND EQUIPMENT USED : DPT/4' Acetate Sleeve

WATER LEVELS : | START: 10/7/05 | END: 10/7/05 | LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	27"	1		0'-1.75' No recovery 1.75'-2.0' FILL, medium to coarse sand, some gravel 2.0'-4.0' No recovery	
5	4'-8'	36"	2		4.0'-5.0' No recovery 5.5'-6.5' Silty CLAY with organics, ML, dark grey (10YR 4/1) 6.5'-7.1' Silty SAND with gravel, SM, light yellow brown (2.5Y 6/4)	Sample LS11-SB801-UC collected from 6.0-8.0' bgs
10	8'-12'	42"	3		7.1'-8.0' Medium SAND, SB, light yellow brown (2.5Y 6/3), moist 8.0'-8.5' No Recovery 8.5'-10.0' Medium SAND, SB, light yellow brown (2.5Y 6/3), moist 10.0'-12.0' Medium SAND, SB, olive yellow (2.5Y 6/6), moist	
15	12'-16'	48"	4		12'.0-13.0' Silty fine SAND, SM, light yellowish brown (2.5Y 6/3) 13.0'-14.5' Silty fine SAND, SM, olive yellow (2.5Y 6/8), saturated 14.5'-16.0' SAND, SP, light grey (5Y 7/1)	
20	16'-20'	24"	5		16.0'-18.0' No recovery 18.0'-18.7' Coarse SAND, SP, grey (FY 6/1) 18.7'-19.5' Coarse-med. SAND, SW, light olive brown(2.5Y 5/4), well graded, coarsening 19.5'-20.0' Silty clay, ML, dark grey (2.5Y 4/1), medium dense, shell hash at 19.7'	Sample LS11-SB801-LC collected from 18.0'-19.5' bgs
	20'-24'	48"	6		20.0'-21.0' CLAY, CL, dark grey (2.5Y 4/1), dense, shell hash 21.0'-24.0' CLAY, CL, dark grey (2.5Y 4/1), dense, some organics	Sample LS11-SB801-YC collected from 20.0'-22.0' bgs
25					End of Boring @ 24' bgs	

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
329752.SI.WP	LS11-GP802	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek   DRILLING CONTRACTOR : Parratt-Wolff   LOCATION : Sites 11

ELEVATION : 9.50   NORTHING: 3500828.91   EASTING: 12169519.40

DRILLING METHOD AND EQUIPMENT USED : DPT/4' Acetate Sleeve

WATER LEVELS : 9.0' bgs   START: 10/8/05   END: 10/8/05   LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	48"	1		0.0'-0.5' Organic topsoil 0.5'-2.5' SILT, ML, very dark greyish brown (2.5Y 3/2) 2.5'-4.0' Clayey SILT, ML, light yellowish brown (2.5Y 6/4)	
5	4'-8'	42"	2		4.0'-4.5' No Recovery 4.5'-5.5' Silty CLAY, ML, light yellowish brown (2.5Y 6/4) 5.5'-7.0' Clayey SILT, ML, grey (2.5Y 6/1), medium dense 7.0'-8.0' Fine SAND, SP, olive yellow (2.5Y 6/6)	
10	8'-12'	36"	3		8.0'-9.0' No Recovery 9.0'-10.0' Coarse SAND, SP, grey (2.5Y 6/1), saturated 10.0'-12.0' Fine SAND, SP, grey (2.5Y 6/1)	
15	12'-16'	48"	4		12.0'-13.0' No recovery 13.0'-16.0' Fine SAND, SP, grey (2.5Y 6/1)	Sample LS11-SB802-UC collected from 13.0'-15.0' bgs
20	16'-20'	48"	5		16.0'-18.0' Fine SAND, SP, grey (2.5Y 6/1) 18.0'-20.0' Coarse SAND with gravel, SW, grey (2.5Y 6/1)	Sample LS11-SB802-LC collected from 18.0'-20.0' bgs
	20'-24'	48"	6		20.0'-20.2' Coarse sand with gravel, SW, gray (2.5Y 6/1) 20.2'-24.0' N/A	Sample LS11-SB 802-YC collected from 20.5'-22.5' bgs
25					End of boring @ 24.0' bgs	

CH2MHILL	PROJECT NUMBER 329752.SI.WP	BORING NUMBER LS11-GP803	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek DRILLING CONTRACTOR : Parratt-Wolff LOCATION : Site 11

ELEVATION : 9.60 NORTHING: 3500796.29 EASTING: 12169592.16

DRILLING METHOD AND EQUIPMENT USED : DPT/ 4' Acetate Sleeve

WATER LEVELS : 6.0' bgs START: 10/8/05 END: 10/8/05 LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	48"	1		0.0'-0.5' Top soil 0.5'-2.0' SILT, ML, light olive brown (2.5Y 5/3), medium dense 2.0'-2.5' Fill material 2.5'-4.0' Silty CLAY, ML, olive yellow (2.5Y 6/6)	
5	4'-8'	48"	2		4.0'-5.0' Silty CLAY, ML, olive yellow (2.5Y 6/6), mois 5.0'-8.0' Medium SAND, SP, light grey (2.5Y 6/8), saturated, iron staining	
10	8'-12'	48"	3		8.0'-12.0' Medium SAND, SP, olive yellow (2.5Y 6/8, saturated	
15	12'-16'	36"	4		12.0'-13.0' No recovery 13.0'-16.0' Medium SAND, SP, olive yellow (2.5Y 6/8), saturated	
20	16'-20'	18"	5		16.0'-18.5' No recovery 18.5'-19' Coarse SAND with gravel, SW, yellowish brown (10YR 5/8) 19'-20' Silty sand, SM 20' Clay, CL, greenish gray (Gley1 5/5GY 5/1)	Sample LS11-SB803 collected from 18.0'-20.0' bgs
25					End of boring @ 20.0' bgs	

CH2MHILL	PROJECT NUMBER 329752.SI.WP	BORING NUMBER LS11-GP804	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek   DRILLING CONTRACTOR : Parratt-Wolff   LOCATION : Site 11
ELEVATION : 9.50   NORTHING: 3500857.18   EASTING: 12169581.12
DRILLING METHOD AND EQUIPMENT USED : DPT/ 4' Acetate Sleeve
WATER LEVELS : 7.5' bgs   START: 10/7/05   END: 10/7/05   LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	36"	1		0.0'-0.5' Asphalt 0.5'-2.7' SILT with clay lens, ML, brown (10YR 4/3), dry, medium dense 2.7'-3.2' Fine SAND, SP, light olive brown (2.5Y 5/3), dry, loose 3.2'-4.0' Clayey SILT, ML, light olive brown (2.5Y 5/6) dense	
5	4'-8'	48"	2		4.0'-5.6' Silty CLAY, ML, light olive brown (2.5Y 5/6), medium dense, sand lense at 4.2'-4.4' 5.6'-8.0' Medium SAND, SP, light yellowish brown (2.5Y 6/4), saturated, loose, iron staining	
10	8'-12'	36"	3		8.0'-9.0' No recovery 9.0'-11.0' Medium SAND, SP, light yellowish brown (2.5Y 6/4) 11.0'-12.0' Fine SAND, SP, light yellowish brown (2.5Y 6/4), saturated	
15	12'-16'	36"	4		12.0'-13.0' No recovery 13.0'-15.5' Fine SAND, SP, light grey (2.5Y 7/1), iron staining	
20	16'-20'	36"	5		15.5'-16.0' Coarse clean SAND, SP, grey (2.5Y 5/1) 16.0'-17.0' No recovery 17.0'-19.5' Fine SAND, SP, grey (2.5Y 5/1), coarsening upward	
	20'-24'	48"	6		19.5'-20.0' Fine SAND, SP, olive yellow (2.5Y 6/8) 20.0'-24.0' Fine SAND, SP, olive yellow (2.5Y 6/8), iron staining from 23.5' to 24.0'	Samples LS11-SB804-LC and LS11-SB804P-LC collected from 22.0'-24.0' Sample LS11-GW804 collected
25	24'-28'	48"	7		24.0'-24.5' Clay, CL, olive yellow (2.5Y 6/6) 24.5'-25.0' Clay, CL, dark grey (2.5Y 4/1), some organics 25.0'-28.0' Clay, CL, yellow (2.5Y 7/6), dense	
					End of boring @ 28.0' bgs	

CH2MHILL	**PROJECT NUMBER** 329752.SI.WP
	BORING NUMBER **LS11-GP805** SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek DRILLING CONTRACTOR : Parratt-Wolff LOCATION : Site 11

ELEVATION : 9.50 NORTHING: 3500906.49 EASTING: 12169541.48

DRILLING METHOD AND EQUIPMENT USED : DPT/ 4' Acetate Sleeve

WATER LEVELS : 6.0' bgs START: 10/8/05 END: 10/8/05 LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	48"	1		0.0'-0.5' SILT, ML, olive (2.5Y 4/4), dense	
					0.5'-4.0' SILT, ML, olive yellow (2.5Y 6/6), very dense	
	4'-8'	48"	2			
5					4.0'-5.5' SILT, ML, olive yellow (2.5Y 6/6), very dense	
					5.5'-8.0' Medium SAND, SP, pale yellow (2.5Y 7/3), saturated, iron staining	
	8'-12'	36"	3		8.0'-9.0' No recovery	
					9.0'-10.0' Fine SAND, SP, yellow (2.5Y 7/6)	
10					10.0'-12.0' Fine SAND, SP, olive yellow (2.5Y 6/8)	Sample LS11-SB805-UC collected from 10.0'-12.0' bgs
	12'-16'	36"	4		12.0'-13.0' No recovery	
					13.0'-15.0' Silty SAND, SM, olive yellow (2.5Y 6/8), dark purple stain at 13.5'	
15					15.0'-15.4' Coarse SAND with gravel, SW, light grey (2.5Y 7/1)	
					15.4'-15.6' Coarse SAND with gravel, SW, olive (2.5Y 4/4)	
	16'-20'	48"	5		15.6'-16.0' Coarse SAND with gravel, SW, olive yellow (2.5Y 6/8)	
					16.0'-17.5' Fine SAND, SP, olive yellow (2.5Y 6/8)	
					17.5'-19.5' Silty CLAY, ML, pale yellow (2.5Y 7	
20					19.5'-20.0' CLAY, CL, pale yellow (2.5Y 7/3), some gravel, mottled with red inclusions	
	20'-24'	48"	6		20.0'-22.5' Fine silty SAND, SM, light grey (2.5Y 7/1), loose	Sample LS11-SB805-LC collected
					22.5'-24.0' Silty CLAY with organics, dark grey (2.5Y 4/1)	
	24'-28'	48"	7		24.0'-28.0' Clay with organics, CL	
25						Sample LS11-SB805-YC collected
					End of boring @ 28.0' bgs	

CH2MHILL	**PROJECT NUMBER** 329752.SI.WP	**BORING NUMBER** **LS11-GP806** SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek DRILLING CONTRACTOR : Parratt-Wolff LOCATION : Site 11
ELEVATION : 9.40 NORTHING: 3500973.76 EASTING: 12169532.73
DRILLING METHOD AND EQUIPMENT USED : DPT/ 4' Acetate Sleeve
WATER LEVELS : 6.0 bgs START: 10/7/05 END: 10/7/05 LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	48"	1		0.0'-3.0' SILT, ML, Olive Brown (2.5Y 4/3), loose 3.0'-4.0' Silty CLAY, ML, light olive brown (2.5Y 5/6), dense	
5	4'-8'	48"	2		4.0'-4.4' SILT, ML, light olive brown (2.5Y 6/6) 4.4'-6.0' CLAY, CL, olive yellow (2.5Y 6/6), dense, some silt 6.0'-8.0' SAND, SP, olive yellow (2.5Y 6/6), saturated loose, some gravel	PID = 5 ppm
10	8'-12'	36"	3		8.0'-9.0' No recovery 9.0'-12.0' Medium SAND, SP, loose, iron staining 11.0'-12.0'	Sample LS11-SB806-UC collected from 8.0'-10.0' bgs
	12'-16'	48"	4		12.0'-13.0' Medium SAND, SP, loose 13.0'-15.0' Medium SAND, SP, light grey (2.5Y 7/2), loose	
15					15.0'-15.3' Medium SAND, SP, light grey (2.5Y 6/6), loose 15.3'-16.0' Medium SAND, SP, light grey (2.5Y 7/2)	
	16-'20'	48"	5		16.0'-20.0' Gravelly, medium to coarse SAND, SW, light olive brown (2.5Y 5/3), saturated, loose	Sample LS11-SB806-LC collected from 16.0'-18.0' bgs
20	20'-24'	48"	6		20.0'-24.0' CLAY, CL, dark drey (2.5Y 4/1), shell hash	Sample LS11-SB806-YC collected
25					End of boring @ 24.0' bgs	

CH2MHILL	PROJECT NUMBER 329752.SI.WP	BORING NUMBER LS11-GP807	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : NAB Little Creek | DRILLING CONTRACTOR : Parratt-Wolff | LOCATION : Site 11

ELEVATION : 9.50 | NORTHING: 3500919.18 | EASTING: 12169563.42

DRILLING METHOD AND EQUIPMENT USED : DPT/ 4' Acetate Sleeve

WATER LEVELS : | START: 10/8/05 | END: 10/8/05 | LOGGER : A. Jones/M. Ost

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
	0'-4'	48"	1		0.0'-0.5' Topsoil 0.5'-3.0' SILT, ML, dark greyish brown (2.5Y 4/2), dense 3.0'-4.0' Construction fill	
5	4'-8'	48"	2		4.0'-4.6' Clayey SILT, ML, light olive brown (2.5Y 5/6) some construction fill 4.6'-7.2' Clayey SILT, ML, grey (2.5Y 6/1), saturated 7.2'-8.0' Silty SAND with gravel, SW, light olive brown (2.5Y 5/4)	
10	8'-12'	48"	3		8.0'-11.0' Clean SAND, SP, olive yellow (2.5Y 6/6) 11.0'-12.0' Clean SAND, SP, pale yellow (2.5Y 7/3)	
15	12'-16'	36"	4		12.0'-13.0' No recovery 13.0'-13.9' Medium SAND, dark grey (2.5Y 4/1), mois 13.9'-16.0' Fine SAND, SP, light brownish grey (2.5Y 6/2), loose	Sample LS11-SB807-UC collected from 13.0'-15.0' bgs
20	16'-20'	42"	5		16.0'-16.5' No Recovery 16.5'-18.0' Medium SAND, SP, greyish brown (2.5Y 5/2) 18.0'-20.0' Coarse SAND, SP, greyish brown (2.5Y 5/2)	
	20'-24'	48"	6		20.0'-21.0' Coarse SAND, SW, grey (2.5Y 5/1) 21.0'-21.5' Clayey SILT, ML, olive brown (2.5Y 4/3) 21.5'-24.0' CLAY with shells, CL, loose	Sample LS11-SB807-LC collected from 20.0'-22.0' bgs Sample LS11-SB807-YC collected from 22.0'-24.0' bgs
25					End of boring @ 24.0' bgs	

Attachment B

Attachment B-1
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Station ID	LS11-GP804	LS11-MW01T	LS11-MW02S	LS11-MW03T	LS11-MW04D		LS11-MW05D			LS11-MW05S	LS11-MW06D	LS11-MW07D	LS11-MW08D	LS11-MW09D	
Sample ID	LS11-GW804-LC	LS11-MW01T-05A	LS11-MW02S-05A	LS11-MW03T-05A	LS11-MW04D-05A	LS11-MW04D-05D	LS11-MW05D-05A	LS11-MW05D-05D	LS11-MW05DP-05D	LS11-MW05S-05A	LS11-MW06D-05A	LS11-MW07D-05A	LS11-MW08D-05A	LS11-MW09D-05A	LS11-MW09DP-05A
Sample Date	10/07/05	04/01/05	04/01/05	03/31/05	03/30/05	10/10/05	03/30/05	10/10/05	10/10/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05
Chemical Name															
Volatile Organic Compounds (UG/L)															
1,1,1-Trichloroethane	2 J	1 J	10 U	10 U	320	64	190	28	27	10 U	10 U	10 U	1 J	280	240
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J
1,1-Dichloroethane	2.5 J	35	10 U	10 U	600	340	280	160	180	10 U	10 U	10 U	2 J	150	150 J
1,1-Dichloroethene	10 U	2 J	10 U	10 U	140	77	29	8 J	8.8 J	10 U	1 J	10 U	4 J	220	240
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,2-Dibromo-3-chloropropane	10 U	10 R	10 R	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,2-Dibromoethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,2-Dichloroethane	10 U	10 U	10 U	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,2-Dichloroethene (total)	NA	25	5 J	2 J	3,500	NA	1,000	NA	NA	10 U	26	10 U	29	540	560
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
2-Butanone	10 U	10 U	10 U	10 U	10 U	10 U	6 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
2-Hexanone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
4-Methyl-2-pentanone	7.8 J	3 J	10 U	10 U	1,800	40 J	530	200 J	200 J	10 U	10 U	10 U	10 U	10 U	10 UJ
Acetone	10 U	10 U	10 U	10 U	41	10 U	180	190	160	10 U	5 J	10 U	10 U	10 U	10 UJ
Benzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Bromoform	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Carbon disulfide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Chloroform	10 U	10 U	10 U	10 U	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 J	2 J
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Cumene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Cyclohexane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Dichlorodifluoromethane (Freon-12)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Ethylbenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Methyl acetate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Methylcyclohexane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Methylene chloride	10 U	1 B	1 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 B	10 U	10 U	10 U	1 B
Styrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Toluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Trichloroethene	22	21	10 U	10 U	29	8.8 J	10 U	10 U	10 U	10 U	30	10 U	20	1,500	1,400
Trichlorofluoromethane(Freon-11)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Vinyl chloride	10 U	49	1 J	10 U	74	100 J	400	170 J	180 J	10 U	6 J	10 U	10 U	10 U	10 UJ
Xylene, total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
cis-1,2-Dichloroethene	15	25	5 J	2 J	3,500	1,200	1,000	310	320	10 U	26	10 U	29	540	560
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ
m- and p-Xylene	NA	10 U	10 U	10 U	10 U	NA	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	10 UJ
o-Xylene	NA	10 U	10 U	10 U	10 U	NA	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	10 UJ
trans-1,2-Dichloroethene	10 U	10 U	10 U	10 U	7 J	10 U	3 J	10 U	10 U	10 U	10 U	10 U	10 U	3 J	3 J
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ

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Station ID		LS11-MW10D		LS11-MW11D		LS11-MW13D	LS11-MW14D	LS11-MW17D	LS11-MW18Y	LS11-MW19Y		LS11-MW20Y	LS11-MW23D	
Sample ID	LS11-MW09D-05D	LS11-MW10D-05A	LS11-MW10D-05D	LS11-MW11D-05A	LS11-MW11DP-05A	LS11-MW13D-05A	LS11-MW14D-05A	LS11-MW17D-05A	LS11-MW18Y-05A	LS11-MW19Y-05A	LS11-MW19YP-05A	LS11-MW20Y-05A	LS11-MW23D-05A	LS11-MW23D-05D
Sample Date	10/10/05	03/29/05	10/10/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/30/05	03/31/05	10/10/05
Chemical Name														
Volatile Organic Compounds (UG/L)														
1,1,1-Trichloroethane	42	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	84	7.4 J
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	10 U
1,1-Dichloroethane	54	3 J	3.9 J	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	760	1,300
1,1-Dichloroethene	30	34	58	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	14	17
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 R	10 U
1,2-Dibromoethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 J	2.7 J
1,2-Dichloroethene (total)	NA	10 J	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000	NA
1,2-Dichloropropane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	7 J	10 U
2-Hexanone	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	110	160 J
Acetone	10 U	5 J	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	140	10 U
Benzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	10 U	1 J	1.4 J	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cumene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dichlorodifluoromethane (Freon-12)	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl acetate	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylcyclohexane	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2 B	10 U
Styrene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1.3 J
Trichloroethene	140	280	370	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	7 J	13
Trichlorofluoromethane(Freon-11)	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	3,200	5,500
Xylene, total	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	360	10 J	12	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1,000	1,100
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m- and p-Xylene	NA	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	NA
o-Xylene	NA	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	NA
trans-1,2-Dichloroethene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	13	11
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

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Station ID	LS11-MW24D	LS11-MW25D		LS11-MW26D		LS11-MW27D	LS11-MW28D	LS11-MW29D	LS11-MW30D	LS11-MW36D		LS11-MW37D
Sample ID	LS11-MW24D-05A	LS11-MW25D-05A	LS11-MW25D-05D	LS11-MW26D-05A	LS11-MW26D-05D	LS11-MW27D-05A	LS11-MW28D-05A	LS11-MW29D-05A	LS11-MW30D-05A	LS11-MW36D-05A	LS11-MW36DP-05A	LS11-MW37D-05A
Sample Date	03/31/05	03/31/05	10/11/05	03/31/05	10/11/05	03/31/05	03/30/05	03/31/05	03/31/05	04/01/05	04/01/05	04/01/05
Chemical Name												
Volatile Organic Compounds (UG/L)												
1,1,1-Trichloroethane	50 U	32,000	27,000 L	17	190 J	10 UJ	12,000	1,400	2,100	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,1,2-Trichloroethane	50 U	2,000 U	14	10 U	10 U	10 UJ	15	100 U	200 U	10 U	10 U	10 U
1,1-Dichloroethane	10 J	12,000	12,000 L	170	940 L	520	4,000	920	2,600	10 U	10 U	4 J
1,1-Dichloroethene	8 J	2,700	3,900 L	1 J	10 J	10 UJ	2,700	87 J	390	10 U	10 U	70
1,2,4-Trichlorobenzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane	50 U	2,000 U	10 U	10 U	10 U	50 R	10 U	100 R	5,000 R	10 R	10 R	40 R
1,2-Dibromoethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,2-Dichlorobenzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,2-Dichloroethane	50 U	2,000 U	10 U	10 U	1.9 J	10 UJ	23	100 U	200 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	160	300,000	NA	19	NA	25 J	60,000	3,600	47,000	10 U	10 U	3 J
1,2-Dichloropropane	50 U	2,000 U	22	10 U	10 U	10 UJ	8 J	100 U	200 U	10 U	10 U	10 U
1,3-Dichlorobenzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
1,4-Dichlorobenzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
2-Butanone	26 J	2,000 U	10 U	4 J	45 J	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
2-Hexanone	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
4-Methyl-2-pentanone	1,900	1,500 J	2,200 J	640 J	1,600 L	37 J	3,000	1,000	610	10 U	10 U	10 U
Acetone	51	1,500 J	1,100 J	51	820 L	10 UJ	370	240	340	10 U	10 U	10 U
Benzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Bromodichloromethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	2 J	2 J	10 U
Bromoform	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Bromomethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Carbon disulfide	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Carbon tetrachloride	50 U	2,000 U	1,300 J	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Chlorobenzene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Chloroethane	970	2,000 U	10 U	10 U	10 U	32 J	10 U	100 U	200 U	10 U	10 U	10 U
Chloroform	50 U	2,000 U	10 U	10 U	10 U	10 UJ	13	100 U	200 U	6 J	6 J	10 U
Chloromethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Cumene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Cyclohexane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Dibromochloromethane	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Dichlorodifluoromethane (Freon-12)	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Ethylbenzene	50 U	2,000 U	3.8 B	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methyl acetate	50 U	2,000 U	10 U	10 U	16 J	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methyl-tert-butyl ether (MTBE)	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methylcyclohexane	50 U	2,000 U	2 J	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Methylene chloride	12 B	2,800	7,100 L	10 U	10 U	2 B	470	23 B	140 J	10 U	10 U	2 B
Styrene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Tetrachloroethene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Toluene	50 U	2,000 U	16	10 U	1.6 J	10 UJ	5 J	100 U	200 U	4 J	2 J	5 J
Trichloroethene	50 U	2,000 U	1,200 J	1 J	6.7 J	2 J	24	100 U	53 J	3 J	2 J	230
Trichlorofluoromethane(Freon-11)	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
Vinyl chloride	3,000	1,600 J	7,600 L	280 J	3,500 L	140 J	2,300	4,400	5,400	10 U	10 U	10 U
Xylene, total	50 U	2,000 U	16 B	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	160	300,000	260,000 L	19	330 L	25 J	60,000	3,000	47,000	10 U	10 U	3 J
cis-1,3-Dichloropropene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
m- and p-Xylene	50 U	2,000 U	NA	10 U	NA	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
o-Xylene	50 U	2,000 U	NA	10 U	NA	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	50 U	550 J	300 J	10 U	5.9 J	10 UJ	450	100 U	120 J	10 U	10 U	10 U
trans-1,3-Dichloropropene	50 U	2,000 U	10 U	10 U	10 U	10 UJ	10 U	100 U	200 U	10 U	10 U	10 U

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Virginia Beach, Virginia

Station ID	LS11-GP804	LS11-MW01T	LS11-MW02S	LS11-MW03T	LS11-MW04D		LS11-MW05D			LS11-MW05S	LS11-MW06D	LS11-MW07D	LS11-MW08D	LS11-MW09D	
Sample ID	LS11-GW804-LC	LS11-MW01T-05A	LS11-MW02S-05A	LS11-MW03T-05A	LS11-MW04D-05A	LS11-MW04D-05D	LS11-MW05D-05A	LS11-MW05D-05D	LS11-MW05DP-05D	LS11-MW05S-05A	LS11-MW06D-05A	LS11-MW07D-05A	LS11-MW08D-05A	LS11-MW09D-05A	LS11-MW09DP-05A
Sample Date	10/07/05	04/01/05	04/01/05	03/31/05	03/30/05	10/10/05	03/30/05	10/10/05	10/10/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05
Chemical Name															
Total Metals (UG/L)															
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	7,620 J	15,900 J	NA	48,800 J	NA	NA	NA	NA	290 J	511 J	454 J	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	731 J	3,860	NA	7,180	NA	NA	NA	NA	640	52.7	972	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)															
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	7,740 J	16,700	NA	47,100	NA	NA	NA	12.4 B	33.7 B	11.7 B	191	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	93.6	NA	NA	810 J	3,930	3,590	7,260	6,900	6,830	NA	0.91 U	65.6	27	916	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Station ID		LS11-MW10D		LS11-MW11D		LS11-MW13D	LS11-MW14D	LS11-MW17D	LS11-MW18Y	LS11-MW19Y		LS11-MW20Y	LS11-MW23D	
Sample ID	LS11-MW09D-05D	LS11-MW10D-05A	LS11-MW10D-05D	LS11-MW11D-05A	LS11-MW11DP-05A	LS11-MW13D-05A	LS11-MW14D-05A	LS11-MW17D-05A	LS11-MW18Y-05A	LS11-MW19Y-05A	LS11-MW19YP-05A	LS11-MW20Y-05A	LS11-MW23D-05A	LS11-MW23D-05D
Sample Date	10/10/05	03/29/05	10/10/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/30/05	03/31/05	10/10/05
Chemical Name														
Total Metals (UG/L)														
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	187 J	NA	21.3 B	33.7 B	443 J	NA	NA	NA	NA	NA	NA	6,090 J	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	215	NA	90.1	99	8.6	NA	NA	NA	NA	NA	NA	51.4 J	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)														
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	8 B	NA	7.73 U	7.73 U	11.5 B	NA	NA	NA	NA	NA	NA	472 J	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	2,300	51.2	128	61.1	62.5	1.4 B	NA	NA	NA	NA	NA	NA	35.3 J	142
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Station ID	LS11-MW24D	LS11-MW25D		LS11-MW26D		LS11-MW27D	LS11-MW28D	LS11-MW29D	LS11-MW30D	LS11-MW36D		LS11-MW37D
Sample ID	LS11-MW24D-05A	LS11-MW25D-05A	LS11-MW25D-05D	LS11-MW26D-05A	LS11-MW26D-05D	LS11-MW27D-05A	LS11-MW28D-05A	LS11-MW29D-05A	LS11-MW30D-05A	LS11-MW36D-05A	LS11-MW36DP-05A	LS11-MW37D-05A
Sample Date	03/31/05	03/31/05	10/11/05	03/31/05	10/11/05	03/31/05	03/30/05	03/31/05	03/31/05	04/01/05	04/01/05	04/01/05
Chemical Name												
Total Metals (UG/L)												
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	71,900 J	NA	10,500 J	NA	NA	NA	NA	NA	174 J	142 J	630 J
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	8,880 J	NA	871 J	NA	NA	NA	NA	NA	61.4 J	58.2 J	160 J
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Metals (UG/L)												
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	67,000 J	NA	9,120 J	NA	NA	NA	NA	NA	19.2 B	17.7 B	39.9 B
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	8,610 J	9,150	1,110 J	3,340	NA	NA	NA	NA	52.9 J	53.1 J	156 J
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Virginia Beach, Virginia

Station ID	LS11-GP804	LS11-MW01T	LS11-MW02S	LS11-MW03T	LS11-MW04D		LS11-MW05D			LS11-MW05S	LS11-MW06D	LS11-MW07D	LS11-MW08D	LS11-MW09D	
Sample ID	LS11-GW804-LC	LS11-MW01T-05A	LS11-MW02S-05A	LS11-MW03T-05A	LS11-MW04D-05A	LS11-MW04D-05D	LS11-MW05D-05A	LS11-MW05D-05D	LS11-MW05DP-05D	LS11-MW05S-05A	LS11-MW06D-05A	LS11-MW07D-05A	LS11-MW08D-05A	LS11-MW09D-05A	LS11-MW09DP-05A
Sample Date	10/07/05	04/01/05	04/01/05	03/31/05	03/30/05	10/10/05	03/30/05	10/10/05	10/10/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05	03/30/05
Chemical Name															
Wet Chemistry (MG/L)															
Alkalinity	14	NA	NA	NA	NA	180	NA	94	96	NA	NA	NA	NA	NA	NA
Chloride	26	NA	NA	NA	NA	55 L	NA	44 L	38 L	NA	NA	NA	NA	NA	NA
Ethane	0.0062 U	NA	NA	0.01 U	0.01 U	0.0062 U	0.01 U	0.0062 U	0.0062 U	NA	NA	0.01 U	0.01 U	0.01 U	NA
Ethene	0.0058 U	NA	NA	0.01 U	0.074	0.066	0.18	0.061	0.072	NA	NA	0.01 U	0.01 U	0.01 U	NA
Methane	0.0063 J	NA	NA	0.19	0.49	0.32 J	0.56	0.15 J	0.17 J	NA	NA	0.081	0.069	0.037	NA
Nitrate	0.1 UJ	NA	NA	0.05 U	0.05 U	0.14	0.42	0.16	0.15	NA	NA	0.58	0.3	0.53	NA
Nitrite	NA	NA	NA	0.05 U	0.0056 J	NA	0.022 J	NA	NA	NA	NA	0.05 U	0.05 U	0.05 U	NA
Nitrogen	0.1 UJ	NA	NA	NA	NA	0.1 U	NA	0.1 U	0.1 U	NA	NA	NA	NA	NA	NA
Sulfate	11	NA	NA	19	21	20	1.7	16	14	NA	NA	17	19	25	NA
Sulfide	NA	NA	NA	1 U	1 U	NA	1 U	NA	NA	NA	NA	0.25 J	1 U	1 U	NA
Total organic carbon (TOC)	4	NA	NA	13	570	520	260	220	230	NA	NA	0.71 J	4.5	210	NA

Notes:
U- Analyte not detected
J- Reported value is estimated
UJ- Analyte not detected. Quantitation limit may be imprecise
L- Reported value is estimated
B- Possible blank contamination
NA- Not analyzed
"P" Identifier on sample ID indicates a duplicate sample
R- Unreliable result

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NAB Little Creek
Virginia Beach, Virginia

Station ID		LS11-MW10D		LS11-MW11D		LS11-MW13D	LS11-MW14D	LS11-MW17D	LS11-MW18Y	LS11-MW19Y		LS11-MW20Y	LS11-MW23D	
Sample ID	LS11-MW09D-05D	LS11-MW10D-05A	LS11-MW10D-05D	LS11-MW11D-05A	LS11-MW11DP-05A	LS11-MW13D-05A	LS11-MW14D-05A	LS11-MW17D-05A	LS11-MW18Y-05A	LS11-MW19Y-05A	LS11-MW19YP-05A	LS11-MW20Y-05A	LS11-MW23D-05A	LS11-MW23D-05D
Sample Date	10/10/05	03/29/05	10/10/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/29/05	03/30/05	03/31/05	10/10/05
Chemical Name														
Wet Chemistry (MG/L)														
Alkalinity	70	NA	8.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	87
Chloride	31 L	NA	49 L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59 L
Ethane	0.0062 U	0.01 U	0.0062 U	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.01 U	0.0062 U
Ethene	0.0058 U	0.01 U	0.0058 U	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.42	0.46
Methane	0.013 J	0.01 U	0.011 J	0.01 U	NA	0.01 U	NA	NA	NA	NA	NA	NA	0.74	0.86 J
Nitrate	0.1 U	1	0.18	1.8	NA	1.5	NA	NA	NA	NA	NA	NA	0.05 U	0.15
Nitrite	NA	0.05 U	NA	0.05 U	NA	0.054	NA	NA	NA	NA	NA	NA	0.014 J	NA
Nitrogen	0.1 U	NA	0.1 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1 U
Sulfate	30	41	44	21	NA	13	NA	NA	NA	NA	NA	NA	5 U	0.1 U
Sulfide	NA	1.2	NA	1.2	NA	1	NA	NA	NA	NA	NA	NA	1 U	NA
Total organic carbon (TOC)	180	0.45 J	1 U	0.49 J	NA	2.4	NA	NA	NA	NA	NA	NA	120	230

Notes:

U- Analyte not detected

J- Reported value is estimated

UJ- Analyte not detected. Quantitation limit may be im|

L- Reported value is estimated

B- Possible blank contamination

NA- Not analyzed

"P" Identifier on sample ID indicates a duplicate sampl

R- Unreliable result

Attachment B-1
Groundwater Analytical Results (March and October 2005)
Pre Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	LS11-MW24D	LS11-MW25D		LS11-MW26D		LS11-MW27D	LS11-MW28D	LS11-MW29D	LS11-MW30D	LS11-MW36D		LS11-MW37D
Sample ID	LS11-MW24D-05A	LS11-MW25D-05A	LS11-MW25D-05D	LS11-MW26D-05A	LS11-MW26D-05D	LS11-MW27D-05A	LS11-MW28D-05A	LS11-MW29D-05A	LS11-MW30D-05A	LS11-MW36D-05A	LS11-MW36DP-05A	LS11-MW37D-05A
Sample Date	03/31/05	03/31/05	10/11/05	03/31/05	10/11/05	03/31/05	03/30/05	03/31/05	03/31/05	04/01/05	04/01/05	04/01/05
Chemical Name												
Wet Chemistry (MG/L)												
Alkalinity	NA	NA	470	NA	250	NA	NA	NA	NA	NA	NA	NA
Chloride	NA	NA	400	NA	66	NA	NA	NA	NA	NA	NA	NA
Ethane	NA	0.01	0.0062 U	0.01 U	0.0062 U	NA	NA	NA	NA	0.01 U	NA	0.01 U
Ethene	NA	0.043	0.066 J	0.15	0.44 J	NA	NA	NA	NA	0.01 U	NA	0.01 U
Methane	NA	0.32	0.37 J	4.9	5.8 J	NA	NA	NA	NA	0.01 U	NA	0.076
Nitrate	NA	0.05 U	0.14 L	0.05 U	0.12 L	NA	NA	NA	NA	0.046 J	NA	0.028 J
Nitrite	NA	0.14	NA	0.008 J	NA	NA	NA	NA	NA	0.05 U	NA	0.05 U
Nitrogen	NA	NA	0.1 U	NA	0.1 U	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	1 U	0.12	1 U	0.24	NA	NA	NA	NA	11	NA	12
Sulfide	NA	0.7 J	NA	1 U	NA	NA	NA	NA	NA	1 U	NA	1 U
Total organic carbon (TOC)	NA	2,600	3,600	290	720	NA	NA	NA	NA	1.3	NA	0.55 J

Notes:
U- Analyte not detected
J- Reported value is estimated
UJ- Analyte not detected. Quantitation limit may be im
L- Reported value is estimated
B- Possible blank contamination
NA- Not analyzed
"P" Identifier on sample ID indicates a duplicate sampl
R- Unreliable result

Attachment B-2
Soil Anaytical Results (October 2005)
Pre-Feasibility Study Investigations
NAB Little Creek
Virginia Beach, Virginia

Station ID	LS11-GP801			LS11-GP802			LS11-GP803	LS11-GP804	
Sample ID	LS11-SB801-UC	LS11-SB801-LC	LS11-SB801-YC	LS11-SB802-YC	LS11-SB802-LC	LS11-SB802-UC	LS11-SB803-LC	LS11-SB804-LC	LS11-SB804P-LC
Sample Date	10/07/05	10/07/05	10/07/05	10/08/05	10/08/05	10/08/05	10/08/05	10/07/05	10/07/05
Chemical Name									
Volatile Organic Compounds (UG/KG)									
1,1,1-Trichloroethane	12 U	93	16 U	15 J	16 J	12 U	12 U	12 U	13 U
1,1,2,2-Tetrachloroethane	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,1,2-Trichloroethane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
1,1-Dichloroethane	2.5 J	38	2,100	3,000 J	7.3 J	7.1 J	4.9 J	12 U	13 U
1,1-Dichloroethene	12 U	5 J	210	620 J	11 U	12 U	12 U	12 U	13 U
1,2,4-Trichlorobenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,2-Dibromo-3-chloropropane	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,2-Dibromoethane	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,2-Dichlorobenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,2-Dichloroethane	12 U	12 U	16 U	6.8 J	11 U	12 U	12 U	12 U	13 U
1,2-Dichloropropane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
1,3-Dichlorobenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
1,4-Dichlorobenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
2-Butanone	12 U	13	16 U	17 U	11 U	12 U	12 U	12 U	13 U
2-Hexanone	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
4-Methyl-2-pentanone	12 U	200	16 U	72 J	14	8.5 J	12 U	12 U	13 U
Acetone	12 U	510 J	16 J	210 J	11 U	12 U	12 U	12 U	13 U
Benzene	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Bromodichloromethane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Bromoform	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Bromomethane	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Carbon disulfide	12 U	12 U	21	40	11 U	12 U	12 U	12 U	13 U
Carbon tetrachloride	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Chlorobenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Chloroethane	12 U	12 U	11 J	34	11 U	12 U	12 U	12 U	13 U
Chloroform	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Chloromethane	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Cumene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Cyclohexane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Dibromochloromethane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Dichlorodifluoromethane (Freon-12)	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Ethylbenzene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Methyl acetate	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Methyl-tert-butyl ether (MTBE)	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Methylcyclohexane	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Methylene chloride	12 U	22 J	530 J	240	11 U	12 U	12 U	12 U	13 U
Styrene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Tetrachloroethene	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Toluene	12 U	12 U	16 U	3.7 J	11 U	12 U	12 U	12 U	13 U
Trichloroethene	6 J	22 J	18,000	25,000 J	17 J	18	23	3 J	25
Trichlorofluoromethane(Freon-11)	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
Vinyl chloride	12 U	7.3 J	16 U	140	11 U	12 U	12 U	12 U	13 U
Xylene, total	12 U	12 U	16 U	17 U	11 U	12 U	12 U	12 U	13 U
cis-1,2-Dichloroethene	11 J	600	130 J	8,100 J	130 J	26	16	8.2 J	9.9 J
cis-1,3-Dichloropropene	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
trans-1,2-Dichloroethene	12 U	12 U	16 U	42	11 U	12 U	12 U	12 U	13 U
trans-1,3-Dichloropropene	12 U	12 U	16 U	17 U	11 UJ	12 U	12 U	12 U	13 U
Wet Chemistry (MG/KG)									
% Solids	86	86	63	60	90	83	85	82	77
Total organic carbon (TOC)	NA	950	12,000	22,000	1,300	NA	NA	NA	NA

Station ID	LS11-GP805			LS11-GP806			LS11-GP807		
Sample ID	LS11-SB805-UC	LS11-SB805-LC	LS11-SB805-YC	LS11-SB806-UC	LS11-SB806-LC	LS11-SB806-YC	LS11-SB807-YC	LS11-SB807-UC	LS11-SB807-LC
Sample Date	10/08/05	10/08/05	10/08/05	10/07/05	10/07/05	10/07/05	10/08/05	10/08/05	10/08/05
Chemical Name									
Volatile Organic Compounds (UG/KG)									
1,1,1-Trichloroethane	12 U	12 U	14 U	12 U	12 U	14 U	5.4 J	3.7 J	180
1,1,2,2-Tetrachloroethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,1,2-Trichloro-1,2,2-trifluoroethane(Freon-113)	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,1,2-Trichloroethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,1-Dichloroethane	12 U	12 U	14 U	12 U	4.1 J	1,800	600 J	4.8 J	110
1,1-Dichloroethene	12 U	12 U	14 U	12 U	12 U	130	75	13 U	15
1,2,4-Trichlorobenzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,2-Dibromo-3-chloropropane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,2-Dibromoethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,2-Dichlorobenzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,2-Dichloroethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,2-Dichloropropane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,3-Dichlorobenzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
1,4-Dichlorobenzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
2-Butanone	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
2-Hexanone	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
4-Methyl-2-pentanone	12 U	12 U	14 U	12 U	7.4 J	14 U	21	5.7 J	240 J
Acetone	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Benzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Bromodichloromethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Bromoform	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Bromomethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Carbon disulfide	12 U	12 U	14 U	12 U	12 U	33	22	13 U	12 U
Carbon tetrachloride	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Chlorobenzene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Chloroethane	12 U	12 U	14 U	12 U	12 U	6.9 J	15 U	13 U	12 U
Chloroform	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Chloromethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Cumene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Cyclohexane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Dibromochloromethane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Dichlorodifluoromethane (Freon-12)	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Ethylbenzene	12 U	12 U	14 U	12 U	12 U	280 J	15 U	13 U	12 U
Methyl acetate	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Methyl-tert-butyl ether (MTBE)	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Methylcyclohexane	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Methylene chloride	12 U	12 U	14 U	12 U	12 U	190	30	13 U	12 U
Styrene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Tetrachloroethene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Toluene	12 U	12 U	14 U	12 U	12 U	1.8 J	15 U	13 U	12 U
Trichloroethene	55	44	3.4 J	20	12 U	11,000	5,400 J	12 J	96
Trichlorofluoromethane(Freon-11)	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Vinyl chloride	12 U	12 U	14 U	12 U	12 U	70	15 U	13 U	12 U
Xylene, total	12 U	12 U	14 U	12 U	12 U	1,200 J	15 U	13 U	12 U
cis-1,2-Dichloroethene	15	12	14 U	4.2 J	14 J	7,700	600 J	22 J	370
cis-1,3-Dichloropropene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
trans-1,2-Dichloroethene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	2.9 J
trans-1,3-Dichloropropene	12 U	12 U	14 U	12 U	12 U	14 U	15 U	13 U	12 U
Wet Chemistry (MG/KG)									
% Solids	82	82	72	87	85	72	66	80	80
Total organic carbon (TOC)	NA	1,400	13,000	NA	970	10,000	10,000	NA	1,600

NA - Not analyzed
J - Reported value is estimated
U - Analyte not detected
UJ - Not detected, quantitation limit may be inaccurate

microbialinsights

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Analysis Report

Client: Felicia Arroyo
CH2M HILL
5700 Cleveland Street
Suite 101
Virginia Beach, VA 23462

Phone: (757) 671-8311

Fax: (757) 497-6885

MI Identifier: 013CJ **Date Rec:** 10/08/2005 **Report Date:** 10/28/2005

Client Project #: 329752.SI.FQ **Client Project Name:** NAB Little Creek Site 11 (CTO-103)

Purchase Order #:

Analysis Requested: CENSUS (final), PLFA, VFA

Comments:

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

Reported By: Michael Saxton

Reviewed By: Greg A. Davis

MICROBIAL INSIGHTS, INC.

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CENSUS

Client: **CH2M HILL**
Project: NAB Little Creek Site 11 (CTO-103)

MI Project Number: **013CJ**
Date Received: 10/08/2005

Sample Information

Client Sample ID:		**LS11-SB801-LC**	**LS11-SB801-YC**	**LS11-SB806-LC**	**LS11-SB802-LC**	**LS11-SB805-LC**
Sample Date:		10/07/2005	10/07/2005	10/07/2005	10/08/2005	10/08/2005
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Dechlorinating Bacteria						
Dehalococcoides spp (1)	*DHC*	**1.11E+06**	<9.58E+02	**3.24E+05**	**2.73E+03**	**1.75E+03**
Dehalobacter spp.	*DHB*	**4.01E+06**	**8.5E+05**	**7.72E+06**	**3.26E+06**	**2.65E+06**
Functional Genes						
BAV1 VC R-Dase (1)	BVC	**1.35E+05**	<9.58E+02	**5.1E+04**	<9.52E+02	<8.28E+02

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

Notes:
1 Bio-Dechlor Census technology was developed by Dr. Loeffler and colleagues at Georgia Institute of Technology and was licensed for use through Regenesis.

MICROBIAL INSIGHTS, INC.

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CENSUS

Client:	**CH2M HILL**	**MI Project Number:**	**013CJ**
Project:	NAB Little Creek Site 11 (CTO-103)	Date Received:	10/08/2005

Sample Information

Client Sample ID:		**LS11-SB807-LC**
Sample Date:		10/08/2005
Units:		cells/g

Dechlorinating Bacteria

Dehalococcoides spp (1)	*DHC*	**3.95E+03**
Dehalobacter spp.	*DHB*	**5.66E+06**

Functional Genes

BAV1 VC R-Dase (1)	BVC	<9.03E+02

Legend:

NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited

< = Result not detected

Notes:

1 Bio-Dechlor Census technology was developed by Dr. Loeffler and colleagues at Georgia Institute of Technology and was licensed for use through Regenesis.

MICROBIAL INSIGHTS, INC.

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PLFA

Client:	**CH2M HILL**	**MI Project Number:**	**013CJ**
Project:	NAB Little Creek Site 11 (CTO-103)	Date Received:	10/08/2005

Sample Information

Sample Name:	**LS11-SB801-LC**	**LS11-SB801-YC**	**LS11-SB806-LC**	**LS11-SB805-LC**
Sample Date:	10/07/2005	10/07/2005	10/07/2005	10/08/2005
Sample Matrix:	Soil	Soil	Soil	Soil
Biomass				
Cells/g	**6.01E+06**	**2.18E+06**	**2.51E+07**	**2.02E+06**
Community Structure (% total PLFA)				
Firmicutes (TerBrSats)	**24.05**	**17.47**	**20.73**	**13.86**
Proteobacteria (Monos)	**30.54**	**25.25**	**36.24**	**24.51**
Anaerobic metal reducers (BrMonos)	**4.90**	**8.33**	**3.85**	**8.49**
SRB/Actinomycetes (MidBrSats)	**1.50**	**2.33**	**5.30**	**3.78**
General (Nsats)	**35.12**	**37.24**	**23.42**	**42.38**
Eukaryotes (polyenoics)	**3.91**	**9.38**	**10.47**	**6.99**
Physiological Status (Proteobacteria only)				
Slowed Growth	**0.76**	**0.60**	**1.48**	**1.55**
Decreased Permeability	**0.33**	**0.22**	**0.18**	**0.18**

Legend:
NA = Not Analyzed   NS = Not Sampled

2340 Stock Creek Blvd. Rockford, TN 37853-3044
Tel: (865) 573-8188; Fax: (865) 573-8133

PLFA

Client: CH2M HILL
Project: NAB Little Creek Site 11 (CTO-103)

MI Project Number: 013CJ
Date Received: 10/08/2005

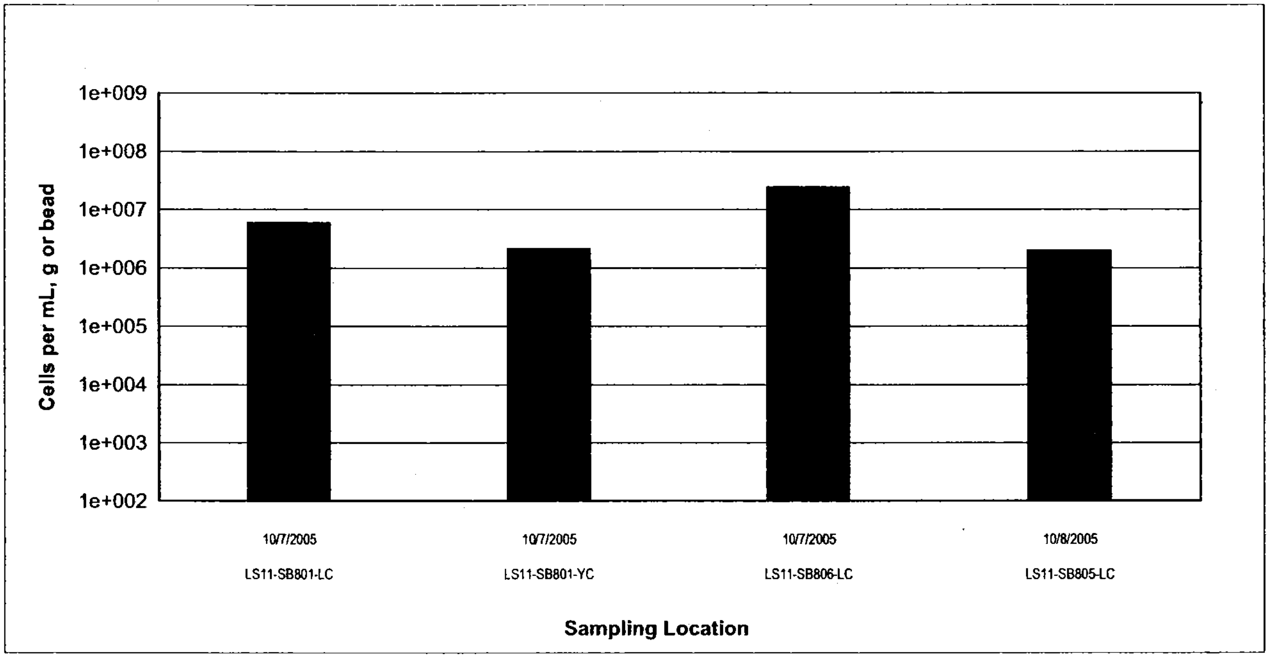

Figure 1. Biomass content is presented as a cell equivalent based on the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Total biomass is calculated based upon PLFA attributed to bacterial and eukaryotic biomass (associated with higher organisms).

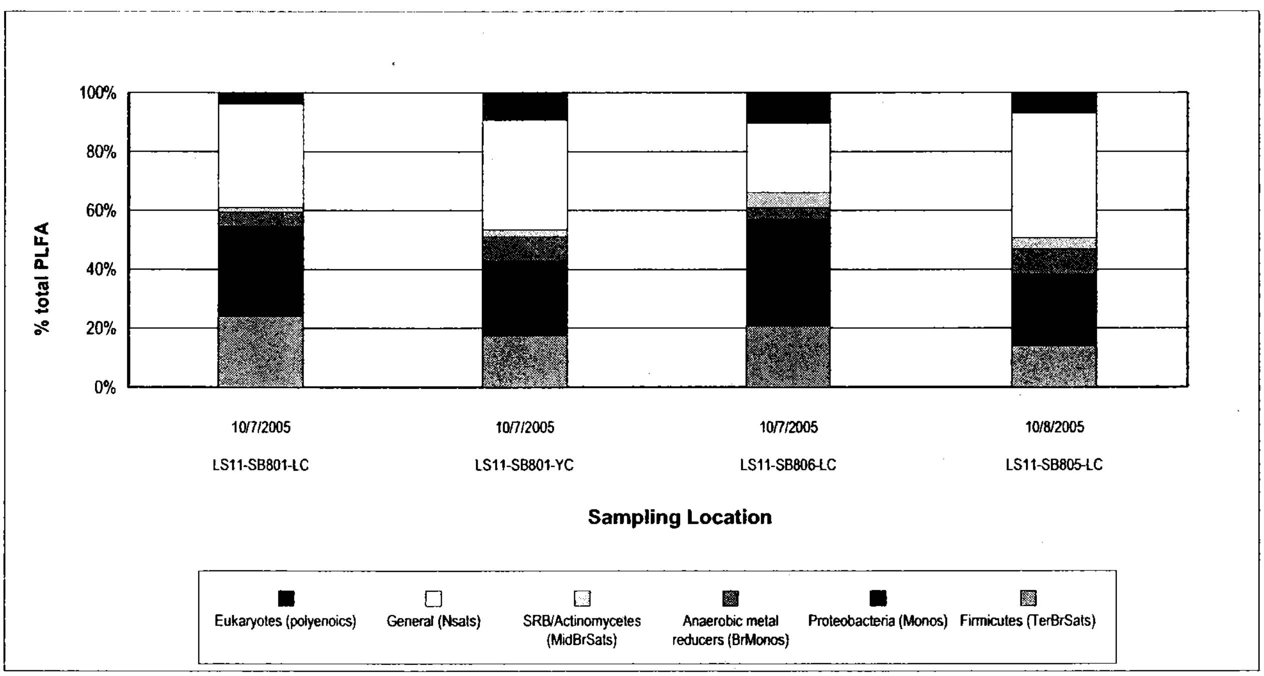

Figure 2. Relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis.

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Analysis Summary Report

Sample Name:	Date Sampled:	Date Received:	Arrival Condition:	Metabolic Acids (mg/L) Pyruvic	Lactic	Formic	Acetic	Propionic	Butyric
LS11-GW804-LC	10/07/2005	10/08/2005	Intact	<4	<1	<1	<1	<1	<1
LS11-MW10D-05D	10/10/2005	10/12/2005	Intact	<4	<1	<1	<1	<1	<1
LS11-MW09D-05D	10/10/2005	10/12/2005	Intact	<4	<1	<1	<1	<1	<1
LS11-MW25D-05D	10/11/2005	10/12/2005	Intact	<4	<1	<1	269.5	192.4	13.8

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Quality Control Report

Compound	MS Recovery %	MSD Recovery %	RPD %	LCS Recovery %
Pyruvic	86.9	85.1	2.1	86.5
Lactic	90.7	91.5	0.9	93.9
Formic	56.9	55.2	3.0	61.0
Acetic	89.8	89.4	0.4	90.1
Propionic	91.3	91.0	0.3	89.1
Butyric	83.1	81.8	1.6	83.5

LABORATORY DATA SUMMARY

Project: CH2M Hill Laboratory Testing 2005
CH2M Hill Project Number: 329753.SI.FQ, CTO # 103
Navy Clean Prime III Contract N62470-02-D-4401
Number: 3687-110
Date: 10/27/05

SAMPLE NUMBER	LS11-SB805-LC	LS11-SB805-YC	LS11-SB806-LC	LS11-SB806-YC
SAMPLE DEPTH	16 to 20	22 to 26	16 to 20	20 to 24
SAMPLE CLASSIFICATION	SM	ML	SP	CH
MOISTURE CONTENT (%)	19.6	43.0	18.5	55.9
% FINER THAN NO. 200 SIEVE	12.8	83.4	4.8	90.5
SPECIFIC GRAVITY	2.651	2.699	2.660	2.722
WET UNIT WEIGHT (pcf)	108.9	115.6	121.4	104.7
DRY UNIT WEIGHT (pcf)	91.1	80.8	102.5	67.2
BULK DENSITY (g/mL)	1.859	1.791	1.874	1.754
POROSITY (%)	49.4	52.0	38.0	60.6

etc.

References: ASTM D 2216, D 854, D 421/422, Soil Engineering

Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name: **CH2M HILL Laboratory Testing 2005**
Number: 3687-110
Project Number: 329752.SI.FQ, CTO #: 103 and "Navy Clean III Prime Contract N62470-02-D-4401"
Sample Number: **LS11-SB806-YC**
Sample Depth: 20 to 24 feet
Sample Description: Silty CLAY (CH), Dark Gray, Trace Fine Sand, Shell Fragments and Organics
Test Method: ASTM D 422

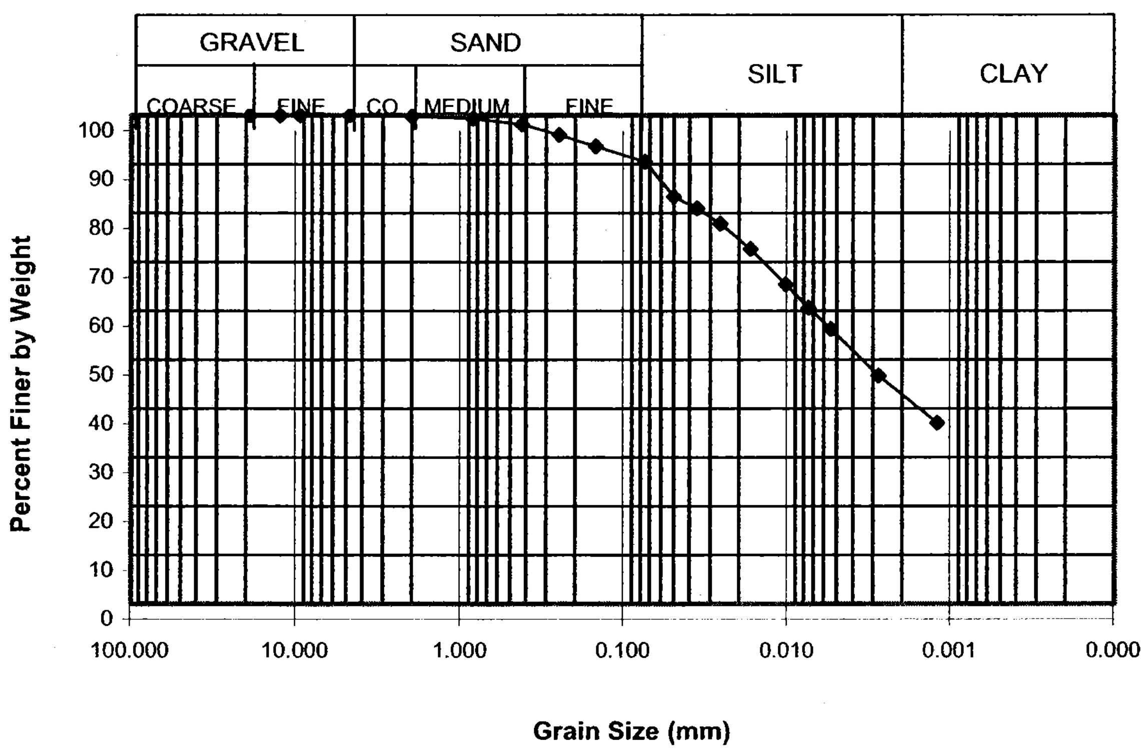
Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	100.0
4	100.0
10	99.8
20	99.3
40	98.2
60	96.0
100	93.6
200	90.5

Hydrometer Analysis Data

DIAMETER (mm)	PERCENT FINER
0.0502	83.4
0.0361	81.0
0.0261	77.8
0.0171	72.7
0.0103	65.5
0.0075	60.6
0.0054	56.3
0.0028	46.7
0.0012	37.0

GRAIN SIZE DISTRIBUTION



Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name:	**CH2M HILL Laboratory Testing 2005**
Number:	3687-110
Project Number:	329752.SI.FQ, CTO #: 103 and "Navy Clean III Prime Contract N62470-02-D-4401"
Sample Number:	**LS11-SB806-LC**
Sample Depth:	16 to 20 feet
Sample Description:	SAND (SP), Tan and Olive Gray, Fine to Medium, Trace Silt
Test Method:	ASTM D 422

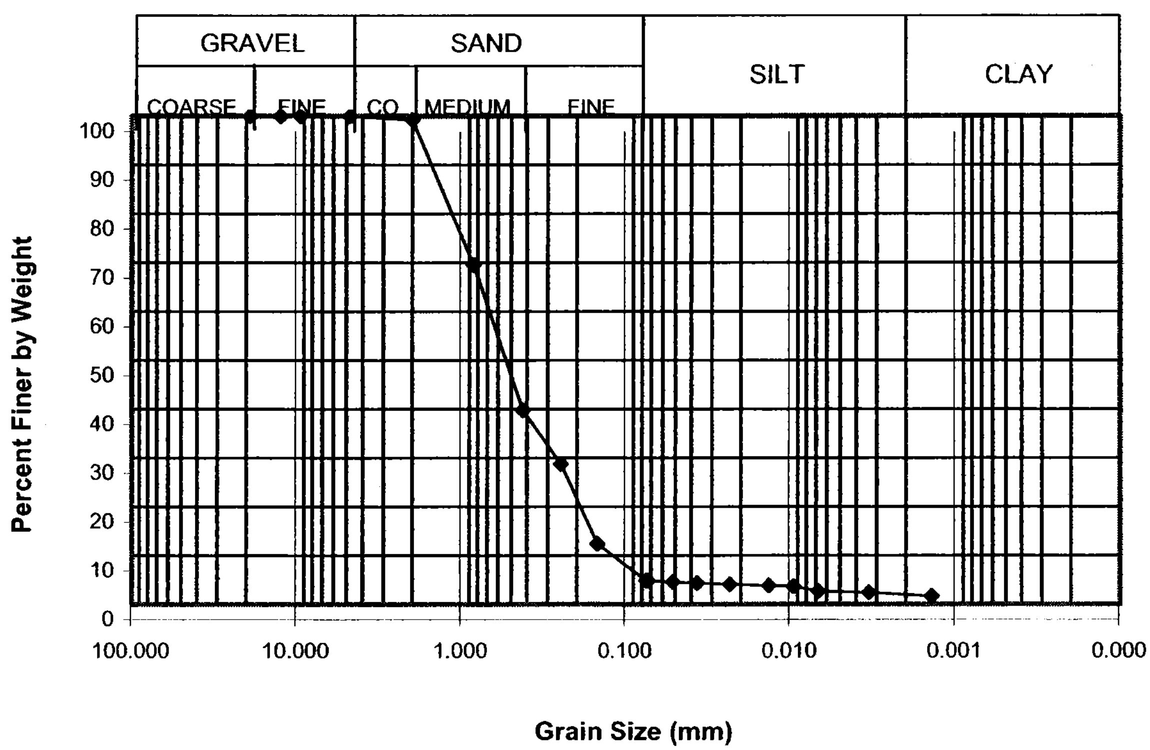
Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	100.0
4	100.0
10	99.2
20	69.5
40	39.8
60	28.8
100	12.4
200	4.8

Hydrometer Analysis Data

DIAMETER (mm)	PERCENT FINER
0.0735	4.8
0.0520	4.6
0.0368	4.4
0.0233	4.1
0.0135	3.9
0.0095	3.6
0.0068	2.7
0.0033	2.4
0.0014	1.7

GRAIN SIZE DISTRIBUTION



Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name:	**CH2M HILL Laboratory Testing 2005**
Number:	3687-110
Project Number:	329752.SI.FQ, CTO #: 103 and "Navy Clean III Prime Contract N62470-02-D-4401"
Sample Number:	**LS11-SB805-YC**
Sample Depth:	22 to 26 feet
Sample Description:	Sandy SILT (ML), Dark Gray, with Clay, Trace Organics
Test Method:	ASTM D 422

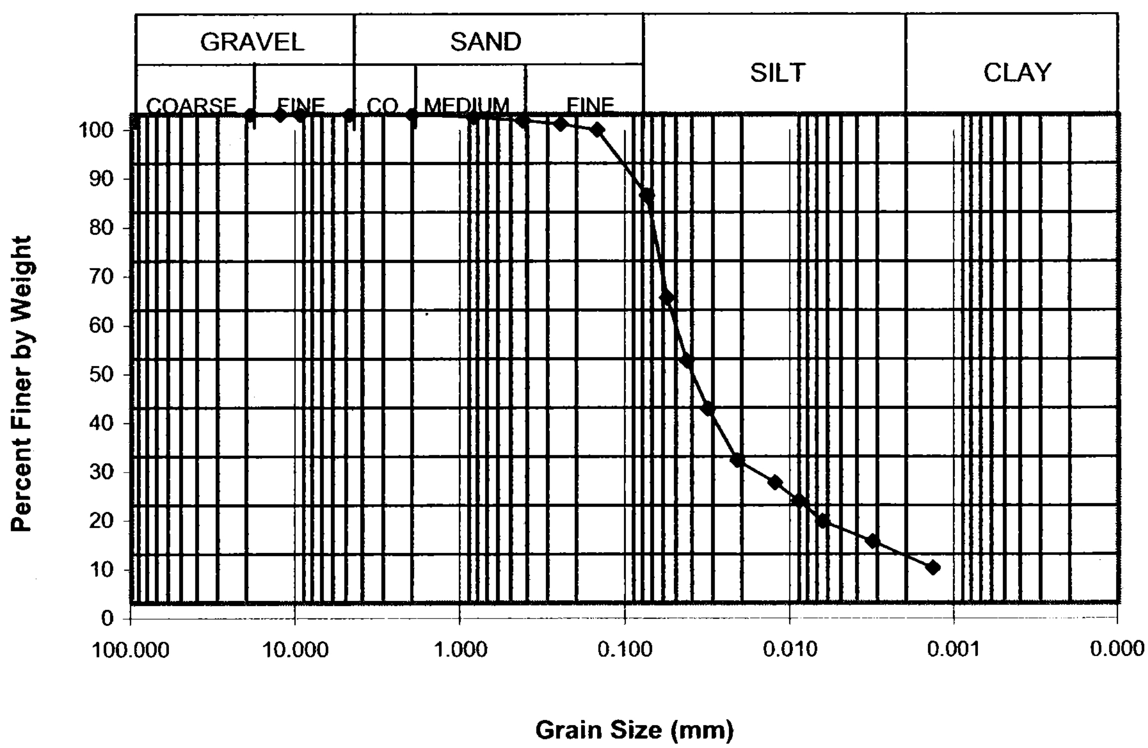
Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	100.0
4	100.0
10	100.0
20	99.5
40	98.8
60	98.1
100	96.9
200	83.4

Hydrometer Analysis Data

DIAMETER (mm)	PERCENT FINER
0.0567	62.6
0.0432	49.7
0.0321	39.8
0.0213	29.2
0.0125	24.7
0.0090	20.9
0.0065	16.7
0.0032	12.6
0.0014	7.2

GRAIN SIZE DISTRIBUTION



Engineering and Testing Consultants, Inc.

SIEVE ANALYSIS

Project Name: **CH2M HILL Laboratory Testing 2005**
Number: 3687-110
Project Number: 329752.SI.FQ, CTO #: 103 and "Navy Clean III Prime Contract N62470-02-D-4401"
Sample Number: **LS11-SB805-LC**
Sample Depth: 16 to 20 feet
Sample Description: Silty SAND (SM), Tan-Orange, Fine to Medium, Trace Clay
Test Method: ASTM D 422

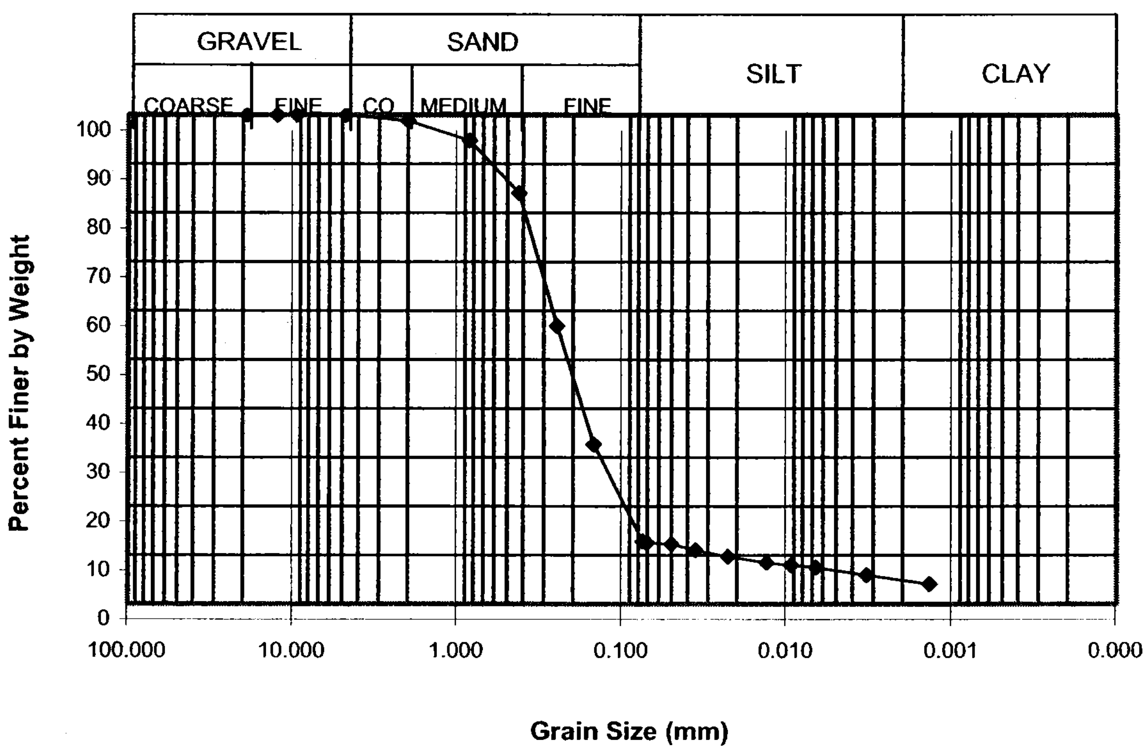
Sieve Analysis Data

SIEVE NO.	PERCENT PASSING
3/4 Inch	100.0
1/2 Inch	100.0
3/8 Inch	100.0
4	100.0
10	98.8
20	94.8
40	84.0
60	57.0
100	32.7
200	12.8

Hydrometer Analysis Data

DIAMETER (mm)	PERCENT FINER
0.0708	12.6
0.0501	12.3
0.0357	11.0
0.0227	9.7
0.0132	8.5
0.0094	8.0
0.0066	7.5
0.0033	5.9
0.0014	4.1

GRAIN SIZE DISTRIBUTION



Appendix C
PRG Calculations

Appendix C Recommended Preliminary Remediation Goals Groundwater Residential Scenario Site 11, NAB Little Creek		
Chemical	**Recommended PRG (mg/L)**	**Basis**
VOCs		
1,1-Dichloroethane	2.9E+00	Child, HQ = 1

Child scenario selected for noncarcinogenic PRGs since child scenario more conservative (lower PRGs).
For constituents with basis of CR = 10^{-5}, PRG for CR =10^{-5} less than PRG for applicable HQ.
Used CR of 10^{-5} to keep overall carcinogenic risk below 10^{-4}.
Applicabe HQ chosen to keep total HI for each target organ below 1.

Appendix D
Applicable or Relevant and Appropriate Requirements

Acronyms and Abbreviations

ARAR	Applicable or relevant and appropriate requirement
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
DCR	Virginia Department of Conservation and Recreation
DNH	Division of Natural Heritage
IDW	Investigation Derived Waste
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NAAQS	National Ambient Air Quality Standards
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NSDWRs	National Secondary Drinking Water Regulations
NSPS	New Source Performance Standards
OSWER	Office of Solid Waste and Emergency Response
PCB	Polychlorinated biphenyls
PMCL	Primary Maximum Contaminant Level
POTW	Publicly Owned Treatment Works
ppm	Parts per Million
RAO	Remedial Action Objective
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
UIC	Underground Injection Control
USACE	US Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
UU/UE	Unlimited Use/Unrestricted Exposure
VAC	Virginia Administrative Code
VMRC	Virginia Marine Resource Commission
VPA	Virginia Pollutant Abatement
VPDES	Virginia Pollutant Discharge Elimination System

References

Commonwealth of Virginia, 2004. Preliminary Identification, Applicable or Relevant and Appropriate Requirements.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final*. Office of Emergency and Remedial Response. EPA/540/G-89/006.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response.

USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Table D-1
Federal Chemical-Specific ARARs
Site 11 Feasibility Study
NAB Little Creek, Virginia Beach, Virginia

Media	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Clean Air Act						
Air	NAAQS specify the maximum concentration of each criteria pollutant (carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, sulfur dioxide) which is to be permitted in the ambient air, as averaged over a period of time. Requirements differ for new sources of air pollutant emissions and existing sources. Requirements also differ based on the air quality designation of the site's location (i.e., attainment, non-attainment, unclassified, or transport) (*see Federal Location-Specific ARARs*).	Emissions of Criteria pollutants during the response action, or during the operation and maintenance of the response action. NAAQSs are not enforceable in and of themselves. However, they may be used as other criteria or guidelines. TBC on appropriate basis.	40 CFR 50.4 to 50.12	2 - ERD	TBC	The Remedy does not involve discharges to air.
				3 - ERH & ERD	TBC	The Remedy will include discharge from an air stripping system, however, VDEQ Administers air permitting programs.
Air	NESHAPS are point-source standards for hazardous air pollutants. These standards address both new and existing sources at the point of emission. Eight hazardous air pollutants (asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride) were initially designated. The 1990 amendments greatly expanded the list of hazardous air pollutants, including 189 new pollutants and designating 174 source categories. Maximum Achievable Control Technology standards were developed for all source categories that emit hazardous air pollutants.	Emissions of hazardous air pollutants from a point source.	40 CFR 61.01 to 61.359	2 - ERD	Not Applicable	This remedial action does not include point source for air emissions.
				3 - ERH & ERD	Applicable	ERH is targeted to treat constituents included on the list of hazardous air pollutants. Vapors generated during the implementation of ERH will be treated.
Safe Drinking Water Act						
Groundwater	SDWA standards serve to protect public water systems. Primary drinking water standards consist of federally enforceable MCLs. MCLs are the highest level of a contaminant that is allowed in drinking water.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 141.11 to 141.16 and 141.61 to 141.66	2 - ERD	Applicable	This remedial action is being implemented with a target goal of achieving MCLs. However, the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.
				3 - ERH & ERD	Applicable	This remedial action is being implemented with a target goal of achieving MCLs. However, the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.
Groundwater	SDWA standards serve to protect public water systems. The MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 141.50 to 141.55	2 - ERD	TBC	Although MCLGs are non-enforceable standards, this remedial action is being implemented with a target goal of achieving MCLs.
				3 - ERH & ERD	TBC	Although MCLGs are non-enforceable standards, this remedial action is being implemented with a target goal of achieving MCLs.
Groundwater	National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 143	2 - ERD	TBC	Although secondary MCLs are non-enforceable standards, this remedial action is being implemented with a target goal of achieving MCLs.
				3 - ERH & ERD	TBC	Although secondary MCLs are non-enforceable standards, this remedial action is being implemented with a target goal of achieving MCLs.
USEPA Region III RBC Tables						
Water, air, fish tissue, soil	Chemical concentrations corresponding to fixed levels of human health risk (i.e., a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration).	Assessment of potential human health risks.	USEPA Region III RBC Tables	2 - ERD	TBC	The RAO is to reduce concentrations in groundwater to the maximum extent practicable with a goal of achieving UU/UE for the site. It is not anticipated that RBCs will be used to establish UU/UE.
				3 - ERH & ERD	TBC	The RAO is to reduce concentrations in groundwater to the maximum extent practicable with a goal of achieving UU/UE for the site. It is not anticipated that RBCs will be used to establish UU/UE.
USEPA Region III BTAG Screening Values						
Soil, sediment, surface water	Chemical concentrations corresponding to fixed levels of risks to ecological receptors (flora and/or fauna).	Assessment of potential ecological risks.	USEPA Region III BTAG Screening Values	2 - ERD	TBC	There are no unacceptable ecological risks at Site 11. Therefore BTAG screening values do not apply.
				3 - ERH & ERD	TBC	There are no unacceptable ecological risks at Site 11. Therefore BTAG screening values do not apply.

Table D-2 Virginia Chemical-Specific ARARs Site 11 Feasibility Study NAB Little Creek, Virginia Beach, Virginia						
Media	**Requirement**	**Prerequisite**	**Citation**	**Alternative**	**ARAR Determination**	**Comment**
State Water Control Law (VA Code Ann. §§ 62.1-44.2 to 62.1-44.34:28 (2003))						
Groundwater	Establishes groundwater quality standards to protect the public health or welfare and enhance the quality of water.	Standards are used when no MCL is available.	*Groundwater Quality Standards*, 9 VAC 25-280	2 - ERD	Applicable	This remedial action is being completed to address concentrations in groundwater.
				3 - ERH & ERD	Applicable	This remedial action is being completed to address concentrations in groundwater.
Environmental Health Services (VA Code Ann. §§ 32.1-163 to 248:2)						
Groundwater	Ensures that all water supplies destined for public consumption be pure water. Cleanup levels for potential drinking water sources must be based on PMCLs. In the absence of PMCLs, other health-based standards or criteria, or best professional judgment based on risk assessment, may be employed. Where groundwater that is a potential drinking water source discharges to surface water, the cleanup level at the discharge point would be the more stringent of either the PMCL or a discharge limit based on the *Water Quality Standards*.	Potential drinking water source.	*Waterworks Regulations*, 12 VAC 5-590-10 to 1280	2 - ERD	Relevant and Appropriate	This ARAR is not applicable because the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply. This remedial action is being implemented with a target goal of achieving MCLs.
				3 - ERH & ERD	Relevant and Appropriate	This ARAR is not applicable because the aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply. This remedial action is being implemented with a target goal of achieving MCLs.
Groundwater	SMCLs are guidelines pertaining to aesthetic qualities of drinking water (i.e., color, odor, and taste).	Potential drinking water source.	*Waterworks Regulations*, 12 VAC 5-590-10 to 1280	2 - ERD	TBC	The aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply. Therefore this criteria does not apply.
				3 - ERH & ERD	TBC	The aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply. Therefore this criteria does not apply.

Table D-3
Federal Location-Specific ARARs
Site 11 Feasibility Study
NAB Little Creek, Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Clean Air Act						
Attainment area (except for ozone)	New major stationary sources/major modifications shall apply "best available control technology" for each regulated pollutant having a potential to emit greater than the associated"significant emission rate." Demonstration that allowable emissions increases or reductions (including secondary emissions) will not cause a significant emissions increase over baseline emissions or contribute to a violation of the NAAQS.	Major stationary sources that emits, or has the potential to emit, 100 tons per year or more of any regulated pollutant; any other stationary source that emits, or has the potential to emit, 250 tons per year or more of any regulated pollutant.	40 CFR 52.21(j)	2 - ERD	Not Applicable	This remedial action does not involve a major new or modified source of regulated air pollutants.
				3 - ERH & ERD	Relevant and Appropriate	This remedial action will include discharge from an air stripping system designed to treat vapors including regulated air pollutants. However, it is not anticipated that the system will be a major source.
Non-attainment area (ozone)	New sources must obtain emissions offsets in Air Quality Control Region of greater than one-to-one. Source subject to "lowest achievable emission rate".	Any new stationary source/modification that directly emits, or has the potential to emit, any air pollutant for which the area is in non-attainment of the NAAQS (including any source of fugitive emissions of any such pollutants).	*Clean Air Act*, Part D §173(1) to (3); 40 CFR 51.18(j)	2 - ERD	Not Applicable	This remedial action does not involve a major new or modified source of regulated air pollutants.
				3 - ERH & ERD	Relevant and Appropriate	This remedial action will include discharge from an air stripping system designed to treat vapors including regulated air pollutants. However, it is not anticipated that the system will be a major source.

Table D-4 Virginia Location-Specific ARARs Site 11 Feasibility Study NAB Little Creek, Virginia Beach, Virginia						
Location	**Requirement**	**Prerequisite**	**Citation**	**Alternative**	**ARAR Determinatio**	**Comment**
Chesapeake Bay Preservation Act (VA Code Ann. §§ 10.1-2100 to 2116)						
Chesapeake Bay and its tributaries	Criteria that provide for the protection of water quality of the Chesapeake Bay and its tributaries, that will also accommodate economic development in Tidewater Virginia. Under these requirements, certain locally designated tidal and nontidal wetlands, as well as other sensitive land areas, may be subject to limitations regarding land-disturbing activities, removal of vegetation, use of impervious cover, erosion and sediment control, stormwater management, and other aspects of land use that may have effects on water quality.	Location is within a Chesapeake Bay Preservation Area.	*Chesapeake Bay Preservation Area Designation and Management Regulations*, 9 VAC 10-20-10 to 260	2 - ERD	Applicable	Site 11 is located within the Chesapeake Bay watershed. However, the remedy will not involve or effect tributaries of the Chesapeake Bay.
				3 - ERH & ERD	Applicable	Site 11 is located within the Chesapeake Bay watershed. However, the remedy will not involve or effect tributaries of the Chesapeake Bay.

Table D-5
Federal Action-Specific ARARs
Site 11 Feasibility Study
NAB Little Creek, Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Resource Conservation and Recovery Act Subtitle C						
Off-site disposal of hazardous wastes	Administrative standards for hazardous wastes sent off-site for further management. Administrative RCRA standards include the obligation to obtain permits and keep various records at all hazardous waste treatment, storage, and disposal facilities; and the requirement to include a hazardous waste manifest when sending hazardous wastes off-site.	Off-site disposal of hazardous wastes.	40 CFR 240 to 282	2 - ERD	Relevant and Appropriate	This remedy will involve offsite disposal of IDW However, based on site history, the IDW is not anticipated to be hazardous. IDW generated during the implementation of this remedial action will be characterized prior to disposal.
				3 - ERH & ERD	Relevant and Appropriate	This remedy will involve offsite disposal of IDW. However, based on site history, the IDW is not anticipated to be hazardous. IDW generated during the implementation of this remedial action will be characterized prior to disposal.

Table D-6
Virginia Action-Specific ARARs
Site 11 Feasibility Study
NAB Little Creek, Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	Alternative	ARAR Determination	Comment
Air Pollution Control Board [VA Code Ann. §§ 10.1-1300 to 1326 (1998)]						
Air emissions from disturbance of soil, treatment of soil or water, or other pollutant management activities	Standards for visible emissions, fugitive dust/emissions, hazardous air pollutants, and toxic pollutants from new and modified sources.	Source of visible emissions, fugitive dust/emissions, and/or a stationary source that emits or may emit any toxic pollutant.	*Standards of Performance for Visible Emissions and Fugitive Dust/Emissions [Rule 5-1]*, 9 VAC 5-50-60 to 120; *USEPA National Emission Standards for Hazardous Air Pollutants [Rule 6-1]*, 9 VAC 5-60-60 to 80; *Emission Standards for Toxic Pollutants from New and Modified Sources [Rule 6-5]*, 9 VAC 5-50-60-300 to 370	2 - ERD	Not Applicable	This remedial action does not involve discharges to air.
				3 - ERH & ERD	Applicable	This remedial action will include discharge from an air stripping system.
Virginia Waste Management Act [VA Code Ann. §§ 10.1-1400 to 1457 (2004)]						
Handling, storage, treatment, disposal, and/or transportation of hazardous waste IDW	Provides for the control of all hazardous wastes that are generated within, or transported to, the Commonwealth for the purposes of storage, treatment, or disposal or for the purposes of resource conservation or recovery. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-12 to 1505; *Regulations Governing the Transportation of Hazardous Materials*, 9 VAC 20-110-10 to 130	2 - ERD	Relevant and Appropriate	This remedy will generate soil and water IDW which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
				3 - ERH & ERD	Relevant and Appropriate	This remedy will generate soil and water IDW which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
Handling, storage, treatment, disposal, and/or transportation of solid waste IDW	Establishes standards and procedures pertaining to the management of solid wastes, and siting, design, construction, operation, maintenance, closure, and post-closure care of solid waste management facilities in this Commonwealth in order to protect the public health, public safety, the environment, and natural resources. Provides the means for identification of open dumping of solid waste and provides the means for prevention or elimination of open dumping of solid waste to protect the public health and safety and enhance the environment. Sets forth the requirements for undertaking corrective actions at solid waste management facilities. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of solid waste.	*Solid Waste Management Regulations*, 9 VAC 20-80-10 to 790	2 - ERD	Applicable	This remedy will generate soil and water IDW which will be characterized for off site disposal.
				3 - ERH & ERD	Applicable	This remedy will generate soil and water IDW which will be characterized for off site disposal.

Appendix E
Preliminary Cost Estimate

COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES

Site: NAB Little Creek
Location: Site 11
Phase: Feasibility Study (-30% to +50%)
Base Year: 2006
Date: January 20, 2005

DISCOUNT RATE
3.1%

Alternative		1 **No Action**		2 **ERD**		3 **ERH & ERD**	
Target		**NA**		**ERD - Source** **ERD - Plume**		**ERH - Source** **ERD - Polishing Source** **ERD - Plume**	
Approach		NA		ERD treatment of target depth interval (~18 - 23 ft bgs)		ERH/ERD treatment of target depth interval (~18 - 23 ft bgs)	
	Number of Years	Cost per Year	**Total Cost**	Cost per Year	**Total Cost**	Cost per Year	**Total Cost**
Capital Cost YEAR 0	1	0	0	$499,000	$499,000	$1,047,000	$1,047,000
Annual Cost YEAR 1-7	7	0	0	$167,367	$1,171,571	--	
Annual Cost YEAR 8-14	7	0	0	$135,928	$951,497	--	
Annual Cost YEAR 1-3	3	0	0	--		$167,367	$502,102
Annual Cost YEAR 4-14	11	0	0	--		$135,928	$1,495,209
Long Term Cost YEAR 15-30 (Long Term Monitoring)	16	0	0	$19,090	$305,440	$19,090	$305,440
Periodic Cost YEAR 0-30 (5-Year Reviews)	6	0	0	$6,900	$41,400	$6,900	$41,400
TOTAL COST			**$0**		**$2,968,908**		**$3,391,151**

PRESENT VALUE COST

Total Net Present Value (Discount rate 3.1%)	**0**		**$2,399,000**		**$2,841,000**

Disclaimer: This estimate is an Order of Magnitude cost estimate, suitable for use in project evaluation and planning. This estimate has been prepared without equipmer specifications, layout, design or engineering calculations. Expected level of accuracy is +50% / -30%. Actual construction costs will vary from this estimate due to market conditions, actual costs of purchased materials, quantity variations, regulatory requirements, final design details and other project-specific factors existing at the time of construction.

Comparison of -30% +50%

Site: NAB Little Creek
Location: Site 11
Phase: Feasibility Study (-30% to +50%)
Base Year: 2006
Date: January 20, 2005

Alternative		1 No Action	2 ERD	3 ERH & ERD
Capital Cost		$0	$499,000	$1,047,000
Range of Estimate	**-30%**	$0	$349,300	$732,900
	+50%	$0	$748,500	$1,570,500
Total Net Present Value (Discount rate 3.1%)		$0	$2,399,000	$2,841,000
Range of Estimate	**-30%**	$0	$1,679,300	$1,988,700
	+50%	$0	$3,598,500	$4,261,500

Alternative 2: **Enhanced Reductive Dechlorination Using Lactate**
Element: **Overall System Components**

Site: NAB Little Creek
Location: Site 11
Phase: Feasibility Study (-30% to +50%)
Base Year: 2006
Date: January 20, 2005

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
PRE-INJECTION ACTIVITIES				$137,925	Engineer's Estimate
YEAR 0 LACTATE INJECTION				$142,888	Recent Similar Project
REPORTING (INJECTION & SAMPLING)				$24,869	Engineer's Estimate
SAMPLING				$107,800	Engineer's Estimate
LAND USE CONTROLS				$20,000	Recent Similar Project
SUBTOTAL				$433,482	
CONTINGENCY	15%	of	$433,482	$65,022	
TOTAL CAPITAL COST				$499,000	

ANNUAL OPERATING COSTS YEAR 1-7

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
LACTATE INJECTION				$81,768	Recent Similar Project
REPORTING (INJECTION & SAMPLING)				$24,869	Engineer's Estimate
SAMPLING				$33,900	Engineer's Estimate
LAND USE CONTROLS				$5,000	Recent Similar Project
SUBTOTAL				$145,537	
CONTINGENCY	15%	of	$145,537	$21,831	
TOTAL ANNUAL OPERATING COST				$167,367	

ANNUAL OPERATING COSTS YEAR 8-14

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
LACTATE INJECTION				$54,430	Recent Similar Project
REPORTING				$24,869	Engineer's Estimate
SAMPLING				$33,900	Engineer's Estimate
LAND USE CONTROLS				$5,000	Recent Similar Project
SUBTOTAL				$118,198	
CONTINGENCY	15%	of	$118,198	$17,730	
TOTAL ANNUAL OPERATING COST				$135,928	

LONG TERM MONITORING YEAR 15-30

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SAMPLING	1	EA	$11,600	$11,600	Engineer's Estimate
LAND USE CONTROLS	1	EA	$5,000	$5,000	Recent Similar Project
SUBTOTAL				$16,600	
CONTINGENCY	15%	of	$16,600	$2,490	
TOTAL ANNUAL OPERATING COST				$19,090	

PERIODIC COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 YEAR REVIEWS				$6,000	Recent Similar Project
CONTINGENCY	15%	of	$6,000	$900	
TOTAL PERIODIC OPERATING COST				$6,900	

PRESENT VALUE ANALYSIS

Based on 3.1% Discount Rate

Note: This estimate is an Order of Magnitude cost estimate, suitable for use in project evaluation and planning. This estimate has been prepared without equipment specifications, layout, design or engineering calculations. Expected level of accuracy is +50% / -30%. Actual construction costs will vary from this estimate due to market conditions, actual costs of purchased materials, quantity variations, regulatory requirements, final design details and other project-specific factors existing at the time of construction.

Alternative 3:	**Electrical Resistance Heating and Enhanced Reductive Dechlorination Using Lactate**
Element:	**Overall System Components**

Site:	NAB Little Creek
Location:	Site 11
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2006
Date:	January 20, 2005

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
ERH SYSTEM & PRE-INJECTION ACTIVITIES				$603,225	Vendor & Engineer's Estimate
YEAR 0 LACTATE INJECTION				$135,086	Recent Similar Project
REPORTING				$24,869	Engineer's Estimate
SAMPLING				$127,100	Engineer's Estimate
LAND USE CONTROLS				$20,000	Recent Similar Project
SUBTOTAL				**$910,279**	
CONTINGENCY	15%	of	$910,279	**$136,542**	
TOTAL CAPITAL COST				**$1,047,000**	

ANNUAL OPERATING COSTS YEAR 1-3

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
LACTATE INJECTION				$81,768	Recent Similar Project
REPORTING				$24,869	Engineer's Estimate
SAMPLING				$33,900	Engineer's Estimate
LAND USE CONTROLS				$5,000	Recent Similar Project
SUBTOTAL				**$145,537**	
CONTINGENCY	15%	of	$145,537	**$21,831**	
TOTAL ANNUAL OPERATING COST				**$167,367**	

ANNUAL OPERATING COSTS YEAR 4-14

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
LACTATE INJECTION				$54,430	Recent Similar Project
REPORTING				$24,869	Engineer's Estimate
SAMPLING				$33,900	Engineer's Estimate
LAND USE CONTROLS				$5,000	Recent Similar Project
SUBTOTAL				**$118,198**	
CONTINGENCY	15%	of	$118,198	**$17,730**	
TOTAL ANNUAL OPERATING COST				**$135,928**	

LONG TERM MONITORING YEAR 15-30

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
SAMPLING				$11,600	Engineer's Estimate
LAND USE CONTROLS				$5,000	Recent Similar Project
SUBTOTAL				**$16,600**	
CONTINGENCY	15%	of	$16,600	**$2,490**	
TOTAL ANNUAL OPERATING COST				**$19,090**	

PERIODIC COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 YEAR REVIEWS				$6,000	Recent Similar Project
CONTINGENCY	15%	of	$6,000	**$900**	
TOTAL PERIODIC OPERATING COST				**$6,900**	

PRESENT VALUE ANALYSIS

Based on 3.1% Discount Rate

Note: This estimate is an Order of Magnitude cost estimate, suitable for use in project evaluation and planning. This estimate has been prepared without equipment specifications, layout, design or engineering calculations. Expected level of accuracy is +50% / -30%. Actual construction costs will vary from this estimate due to market conditions, actual costs of purchased materials, quantity variations, regulatory requirements, final design details and other project-specific factors existing at the time of construction.